THE

# GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE III. VOL. VII.

No. X.—OCTOBER, 1890.

## ORIGINAL ARTICLES.

### I.—On Variations of the Climate.

By Dr. Edw. Jäderin,
of the Royal Swedish Academy of Sciences.

How often do we not hear old people assert that when they were young the climate was quite different; that the weather was warmer or colder, etc.; and even comparatively young people are sometimes of the same opinion. It is most natural to assume that these observers have been misled by the more intense impressions of youth, which cause, for instance, a hot summer, bringing with it more rural pleasures and open-air sports, to be engraved on the mind for life. On the other hand, should the early years be accompanied by much wet weather and storms, these years are perhaps more easily forgotten, as the monotonous and tedious life within four walls to which one is then confined does not leave that distinct impression upon the youthful mind as that of a glorious summer spent out-of-doors. However, the importance of the question and its great general interest demand an investigation of the problem; the more so as certain scientific theories and hypotheses tend to prove that a change in the climate must necessarily take place.

If we assume for a moment that the observations just referred to really were correct, and that besides—as many people also believe—the change, for instance a fall of temperature, steadily continued generation after generation, it will easily be seen that this assumption would lead to absurd results. For, in order to be noticeable in one generation the fall of temperature should at least amount to 1° C., but 1°, say in fifty years, makes 20° in a thousand years, or 40° from the birth of Christ to the present time. If in reality the temperature during these 2000 years has been slightly lowered, the difference cannot, according to the testimony of history, be very considerable, and must, during a generation, be absolutely unnoticeable. Therefore the change which it is assumed has taken place must—if there be any—be *periodical*, *i.e.* that warm and cold periods of varying degree alternate. Indeed, to this conclusion—and a very important one—our experience is led from every-day life. But further than this we are unable to proceed without a systematic scientific basis for our research.

For a long time geological investigation has demonstrated that the climatic conditions of the earth during earlier geological periods

differed greatly from the present. The change referred to must, therefore, be accepted as a fact, but as regards its *nature* there are several probabilities to contend with; for instance, whether it can be traced in a short span of time or at all events in *historical* times, whether it is confined only to *parts* of, or to the *whole* earth, whether it is limited to long or short periods, and, finally, whether the change can be shown to be *still continuing in the same direction.*

The latter question is of course of the highest general interest, as it is closely connected with the history of the earth's development from its first commencement as a planet to its final stage.

In recent times the copious meteorological materials now at our disposal have been analysed, in order to demonstrate the change in the climate within briefer spans of time. It is well known that glaciers are subject to changes in their extension, viz. that during certain periods they advance, and during others retreat beyond their normal limits. Naturally, the cause of this should be sought in the climate, and now, in fact, Forel, Richter, and Lang have demonstrated that this phenomenon in the Alps corresponds with a similar periodicity of temperature and fall of moisture. But the variability of these meteorological factors do not only occur in the Alps, as in 1887 Brückner demonstrated that a periodicity of the rainfall occurs in nearly all countries of the Northern Hemisphere. Of this proof is not only furnished by the rain-gauge, but also by the changes of great duration which take place in rivers, lakes, and in the sea. In the Southern Hemisphere too—as far as we are able to judge from the scanty material at our disposal—a corresponding variability occurs.[1] In fact, according to the latest investigations of Prof. Siegers, of Vienna, upon the level of water in oceans and lakes, this variability of rainfall occurs over the whole surface of the globe.

The temperature of the air, too, is subjected to periodical variations although in a less pronounced degree. On this point it is of interest in winter to study the period during which rivers and lakes are frozen over, as it has been shown that the periodicity coincides with that of the Alpine glaciers.

For the investigation of the circumstances indicated, we have at our disposal material collected at some 500 different meteorological stations, comprising 25,000 years of time of observation, and on the basis of the same we are enabled to declare that the climate of all countries in the world is at a certain time and manner subjected to a change, and that the areas where this is not the case are very limited, indeed they embrace only some coast lines. The varaibility becomes also the more pronounced the further inland we advance.

In the present century the years 1815, 1850, and 1881 mark about the middle of three relatively wet periods, and the years 1830 and 1860 the middle of two correspondingly dry periods.

It would be of interest to know whether the climatic changes are regularly periodical or whether the length of the period suffers any

[1] Vide Stanley's report as to the changes of water-level in the Great Lakes since his last visit.—*Ed.*

alteration in course of time. A long series of records relating to the date of the grape-harvest reaching back to the year 1400, as well as measurements of the level of the water in lakes and rivers up to the year 1700, enable us to fix the average duration of each of the periods in question at 36 years.

The law of the weather theory in general has for a long time been familiar to a large portion of the public. The diurnal synoptic charts show an attentive examiner the connection between the height of the barometer, the direction of the wind, temperature, and rainfall, whilst the charts drawn up for the purpose of showing the annual *means* of the barometer, etc.—*i.e.* the climatic charts—explain the same relation between the meteorological factors. We find, for instance, on one of them somewhere in the Northern Hemisphere an area with an average low pressure, and we shall then also find how the wind, just as on the synoptic charts, which show the state of the weather on a certain occasion, rotates around this area sunwards with a movement towards the centre of the spiral. From this it results that the change noticed in the rainfall must depend upon analogous changes in the direction of the wind and the atmospheric pressure. In a scientific work upon this pressure, based upon observations carried on during many years in Europe and Northern Asia, it is shown that such periodical variations also occur in the barometric pressure.

From observations recorded since 1826 within the Temperate Zone of the Old World, it appears that each rain period, viz. 1841–55, and 1866–85, is followed by a *reduction* of all differences in the barometric pressure, and that each dry period, viz. 1826–40 and 1856–65, is followed by an *increase* of differences in the barometric pressure. Both when speaking of the division of the atmospheric pressure over different *areas* of the earth's surface and in respect of this division during different *seasons* in a certain place, the expression "difference in the atmospheric pressure" is suitable, and a reduction of the differences in the barometric pressure during a certain period indicates a more even division of the pressure than usual over the earth's surface, as well as a smaller variation than the normal during the year.

The change in the barometric pressure explains not only the variation in the rainfall occurring according to the natural law, but also the existence of areas with differing conditions.

Just as on one side the rainfall is dependent upon the variability of the barometric pressure, the latter in turn must exercise influence upon the amount of heat received by the earth, and an increase of the latter during a dry period accentuates the contrast between land and sea.

It would be of additional value to deal with the variations of the climate indicated by Brückner as regards their equal duration and internal relation. They have not only a purely scientific, but a practical importance, as they exercise influence upon changes in the level of lakes and rivers, and thus in many localities the time of their freezing too, and therefore indirectly upon navigation and trade.

Moreover, they directly affect agriculture, particularly on the larger continents. As a proof of this may be mentioned the great increase in the colonization of the North-West American Continent, and the increased rainfall which followed the last dry period, about 1860.

The experience of this comparatively short rainy and stormy period easily explains how people assert that the climate has undergone a change in *one* direction, with just as much justice as other people claim an opposite experience.

Having thus explained the manner in which we may assume that the climate varies periodically or regularly in a uniform or variable manner in different parts of the globe, and that the period extends over 36 years, it would appear from observations that we are at present about the middle of this period, having entered the dry span.

We are, however, aware of other variations occupying much longer periods, which may on account of this greater length exercise a far larger influence upon terrestrial conditions.

We know that Northern Europe even at a comparatively recent geological period was covered with ice, like Greenland at present, and was therefore at that time as uninhabitable as the latter continent is now; but we know, too, that this does not indicate a continuous change in one, certain direction, whereby our climate should steadily become warmer and warmer or that it was equably colder the further we go back in time. For various discoveries made by geologists in the flora and fauna from a period far more remote than the Ice Age show conclusively that at that epoch a climate prevailed in Northern Europe which produced plants and animals similar to those now found in the Tropics. The Ice Age must therefore be considered only an accidental deviation—for a comparatively short period—from the mild climate of pre-Glacial time. To fix the time of this tropical climate is, we must confess, impossible, but the alternating geological strata of the earth appear to indicate that we have here to reckon with hundreds of thousands or may be millions of years.

That this variation in the climate may be connected with the gradual cooling of the earth was formerly an accepted theory, and this with greater reason as it was once assumed that this cooling was general, if not for the whole earth, at all events around the Poles. However, modern *savants* have shown that this is now an untenable theory, as it has been proved that in Japan, for instance, the climate was at a remote period much colder.

At a recent meeting of the Royal Swedish Academy of Sciences Prof. Nathorst demonstrated that the axis of the earth during the geological periods in question has changed its position within the body of the earth itself, and that the North Pole has approached towards us, away from the Japanese side of the earth. From this should have followed a variation of the Polar Meridian of places upon the earth, and this seems also borne out by recent astronomical observations. It has been found that the change is infinitesimal, perhaps only amounting to a second per century, but this second

in a century would in a million years make nearly three degrees, in ten million years nearly thirty degrees, etc., if taking place uniformly with time. The cause of the great change in the climate referred to, and the consequent entire revolution of flora and fauna, must therefore, undoubtedly, with full justification be ascribed to the shifting of the earth's axis, the more so as within the earth and upon its surface transfer of matter is constantly going on, which may again account for this shifting of the axis. These changes again may be considered to be, in spite of the length of time, periodical.[1]

There now remains the great question whether the change in the climate is a continuous one in one direction throughout ages. Geologists and astronomers are, as is generally known, almost agreed upon the theory or hypothesis of the formation and development of the earth, as well as other planets, from a chaotic mass in gas or dust form to its present state. This theory demands that the earth in its earliest stages as a planet should have possessed a very high temperature, being in fact a red-hot ball, which gradually cooled through a number of stages until reaching the present one. According to this, then, the earth should have cooled greatly since its first state as a body, and the conditions upon it should consequently at that period have differed greatly from the present, and that this was so is fully verified by the discoveries from the most remote geological epochs. The question is then : is this change of terrestrial conditions still going on, or has it ceased? There is but little possibility of answering this in the near future, but one thing is certain, we must in our researches towards that end measure time by a gigantic standard.

However, it may be pointed out that there is this difference between the early and present stage of the earth, that during the former it was principally its own producer of heat, receiving most of it from within. The atmosphere was enveloped in large masses of vapour, and filled with heavy clouds, through which the sun's rays never penetrated directly. The sun's heat had therefore little effect, and would, even if it did penetrate to the surface of the earth, have been of subordinate importance to that afforded by the earth itself. Since that stage—the earth having cooled—the rôles have been reversed. The surface of the earth may now be considered as receiving nearly all its heat from the sun. If there be still a glowing interior, the heat shows itself only indirectly through volcanic eruptions and hot springs. Should therefore the earth continue to

[1] See on this subject a most valuable and suggestive memoir "On a Possible Cause of Climatal Changes," by Dr. John Evans, F.R.S., F.S.A., Sec. Geol. Soc. (1866); Proc. Royal Society, March 15th; also, GEOL. MAG. 1866, Vol. III. pp. 171-174, in which a change in the axis of rotation is advocated, not only as best suited to explain the discoveries of an abundant animal- and plant-life in high northern latitudes, demanding great climatal changes; but also those changes due to upheaval, depression, and denudation of the earth's surface which must affect the earth's equilibrium. Also that astronomical observations tend to show "that the ground itself shifts, with respect to the general earth, or that the axis of rotation changes its position.

cool during time, we may assume that the process will affect the temperature on the surface but little.

There may, however, be an indirect effect, viz. that by a decrease of water in the seas through the earth's absorption the moisture of the atmosphere may become reduced, and in return the earth may lose its protecting veil of clouds.

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## II.—The Recent and Rapid Elevation of the Ural Mountains.

By Henry H. Howorth, Esq., M.P., etc.

YOU have permitted me recently to publish two short papers in the Geological Magazine in which I have advocated some unconventional views. Perhaps you will allow me to continue my induction.

In the first paper I endeavoured to show that the identity of the living Mammalian fauna of Siberia and North America necessitates our postulating that those areas have very recently, namely, during the Mammoth age, been connected by a land bridge; further that the facts compel us to the conclusion that this land bridge must have been across a portion of the Polar area, and that when it existed comparatively temperate conditions prevailed there.

In the second paper I endeavoured to show that an elevation of the bed of the Arctic sea sufficiently to permit of such a land bridge existing would entirely reverse the drainage of the great rivers of Western Siberia, which, instead of forcing their waters into the Arctic Ocean, would constitute a great Mediterranean sea in Central Asia; and further, that the débris and relics of this sea preserved in the scattered lakes and intervening sand wastes of that area are among the elementary facts of physical geography.

I went on to argue that when the Mammoth and his companions were living, the general slope of the Siberian continent was like that of European Russia, with which it is so closely connected in other ways, namely, that it sloped down from north to south; the Obi and the Yenissei then having very much the same course that the Ural, the Volga, the Don, and the Dnieper have now. The line separating the two great planes, one of which now slopes northward and the other southward, is the Ural chain. If the change took place at the end of the Mammoth period, a view which I have argued in favour of, we ought to find traces of it, and very patent ones, in the Ural chain itself. The object of this short paper is to point out that this is in fact so, and that the Ural mountains are a very recent feature in the geography of Eastern Europe; that they date from the close of the Mammoth period, and were the result of the violent disturbance of the earth's crust which then occurred, and to which I have elsewhere referred.

The view in regard to the Ural mountains here defended is not entirely new. It had already substantially been advocated by Murchison, under whose broad ægis I am well content to shelter; for I deem him, notwithstanding recent discussions, the first in the long rôle of English geologists.

Thefirst and most obvious fact about the Urals which has struck all travellers who have crossed them is that, although a mountain chain virtually running from one sea to another, they form no frontier at all, either botanically or zoologically. The plants and animals are precisely alike on both sides of the range. It is true that the range is not a very lofty one, nor are other ranges which do constitute biological frontiers; nevertheless it is a very remarkable fact that, so far as we know, the Ural mountains do not form a frontier at all. The continuity of life is complete right across them. They have led to no isolation. It seems to me that this can only be accounted for by the circumstance that they are a very new feature in the country.

Secondly, not only are the zoological and botanical features alike on both sides of the range, but also the superficial loose deposits. Those enigmatic continuous beds of black earth—"chernojem" as the Russians call it—which are such a feature in European Russia, are also found on the Asiatic side of the Urals. Whatever their origin, which, like the origin of the loess, is shrouded in so much doubt, they are clearly not marine, and do not preserve any marine debris whatever, and, whether subaerial or a deposit from fresh water, it remains remarkable that they should be precisely alike in texture and contents on both sides of the chain.

Thirdly, and this is a much more direct piece of evidence. It has been remarked by one traveller after another that there are no traces of glacial action in the Urals. Murchison, who examined the chain from north to south with great care, says, "We have indeed fully explained that those mountains and both their flanks are void of all boulders and far-borne detritus. Though exhibiting proofs of interior dislocation, the Ural is therefore a perfect contrast in this respect to the Scandinavian chain. . . . As there is no glacier in the Ural up to 70° N. lat., so, according to the rules of the glacialist, there never can have been one, since there are no moraines, nor any striated and polished rocks in the whole region" (Russia and the Ural Mountains, pp. 527–8).

In an earlier paper he writes: "To the east of Grabovo, the road runs in one of the lateral depressions, and little stony matter is to be seen. The absence of all coarse detritus is, however, a phenomenon which cannot but surprise every geologist accustomed to other mountain chains, for he has now absolutely reached the foot of the central ridge of the Ural, in which there are many lofty peaks, and yet not a single far-transported block can be detected" (*id.* p. 358–9).

It is not only in the chain itself that we miss these unmistakeable proofs of the existence of former glaciers on a large scale. It is the same in the adjoining plains of European Russia, where all the erratics have come from Scandinavia and Finland.

These facts converge very remarkably upon the conclusion that the Ural chain was non-existent at the time when the Scandinavian Mountains were shedding their boulders far and wide, but that they are in fact a very modern feature in the country. The nature of their contour and the way in which the sheets of auriferous gravel and of Mammoth remains upon them occur point further not only

to their having been recently but also violently and more or less suddenly elevated.

This is what Murchison, who made a very elaborate examination of the whole chain from north to south, has to say on this point: "It must be recollected that as by other proofs we have already endeavoured to show the comparatively recent elevation of the Ural crest, this region cannot be looked upon as having been rendered highly mountainous until the very period when great numbers of these animals (*i.e.* Mammoths) were destroyed—a destruction which we believe to have been mainly accomplished when the present watersheds between Europe and Asia were determined" (Russia and the Ural Mountains, p. 492). Again, he says, "A former terrestrial surface on which the great quadrupeds lived for ages, and the rupture and desiccation of adjacent lakes, coincident with some of the last elevations of the chain, will, we are convinced, best explain the condition in which the remains of the Mammoths are left buried *on the edges of the upturned ridges of the Ural*, as well as in the lowlands and great estuaries furthest removed from them (*id.* p. 494). Again, "Such might have been the position and condition of some of these creatures when, as we have imagined, the highest ridges of the Ural were thrown up, followed by the rupture of many lakes and the consequent inundation of large tracts of the flat country, previously frequented by these great herbivorous animals" (*id.* p. 498). Again, "It has further been proved, that the production of gold veins, and the elevations of the Ural, which have given to these mountains their present height and relief, are phenomena of a comparatively recent date—phenomena which, in lowering the temperature of the great region so affected, were, we have little doubt, the chief causes of the final destruction of the Mammoths, which, with all their adaptation to existence in northern latitudes, could scarcely be supposed to have been capable of long enduring the want of sustenance incident to Siberian winters of the present period" (*id.* p. 605).

I have now brought together such facts as are accessible, illustrating the recent history of the Ural chain, and they seem to me to converge with overwhelming force upon the conclusion that this range of mountains was upheaved more or less rapidly at the end of the Mammoth period. It was this upheaval which, in my view, caused the plain of Siberia to reverse its slope, and its rivers to reverse their drainage, and I agree very much with Murchison's conclusion that it was the floods of water caused by this upheaval which drowned the Mammoths in a considerable area of European and Asiatic Russia, and covered their remains with wide-spreading continuous sheets of gravel and other soft debris. I differ from him in deriving this water from a number of lakes, and would urge, as I urged many years ago, that it was rather the outpouring of the great Asiatic Mediterranean sea, whose relics are so ubiquitous in salt lakes and stretches of marine sand which largely caused the great debacle, and that the upheaval of the Urals was in this way very largely the *causa causans* of the extinction of the Mammoth over a wide area.

Before the upheaval it would seem almost certain that a vast prairie plain stretched from the Carpathians and the Vistula as far as the Yenissei, with a more or less uniform slope towards the south, and draining itself into the vast sheet of water of which the Black Sea, the Caspian Sea, the sea of Aral, and the Balkhash are four notable relics. When the Urals were upheaved, it doubtless set in motion a portion of the waters of this vast sea, which swept over the low country, and distributed the wide-spread mantle of soft deposits far and wide, as we find it spread quite irrespective and independent of the river-valleys.

In another paper you will perhaps allow me to apply the reasoning here used to the Altai and the great plateau of Mongolia.

## III.—Invertebrate Palæontology in some Continental Museums.

By J. Walter Gregory, F.G.S., F.Z.S.,
of the British Museum (Nat. Hist.).

NATURALISTS who refer to their "Baedeker" for information respecting the Continental Natural History Museums are too often disappointed by finding that if the author does happen to have mentioned them, either that he has confined his attention to the exterior of the building or has summarily dismissed the collection as "unimportant." Hence geologists are dependent upon such papers as those in which M. Cotteau[1] has recapitulated the principal contents of several French and Swiss Museums, or that in which Mr. Smith Woodward[2] has enumerated the most interesting specimens of many German and Austrian collections. The last paper, as is indicated by its title, "Vertebrate Palæontology in Continental Museums," is restricted solely to the Vertebrata. But as the value of a Museum, as far as the Invertebrates are concerned, is dependent more on the possession of collections than of single famous specimens, the student of this group is more in need of such information than is the Vertebrate palæontologist; every one knows where he must go to see an *Archæopteryx*, a mounted *Iguanodon*, or a Neanderthal skull, but the last resting-place of a local collector's hoard is, as a rule, less known to fame. Hence the following notes may be of some service as a supplement to Mr. S. Woodward's paper.

### Hamburg.

The palæontological collection is at present mostly stowed away in packing cases at the Johanneum, awaiting removal to its new home in the spacious Museum recently erected in the Steinthorwall. But by the kindness of the Curator, Prof. Dr. Gottsche, I was enabled to examine most of the Echinozoa, especially the valuable series, including some well-preserved Ophiuroids, from the glacial deposits of Northern Germany. There are also collections from the limited exposures of the Oligocene and Cretaceous in the same district. The fossils from Lüneberg are less numerous than in some

[1] "Rapport sur les Musées d'histoire naturelle de quelques-unes des villes du Sud-ouest de la France," Ann. Instit. des provinces, 1868. "Notes sur quelques Musées d'histoire naturelle de la Suisse et de l'Allemagne du Sud," Bull. Soc. Sci. hist. et nat. Yonne. xxiii. 1869.

[2] Geol. Mag. (3) V. 1888, pp. 395-404.

other Museums, no doubt mainly because the local knowledge of the astute curator has enabled him to detect and reject all the specimens imported into that town to make the limited supply more equal to the demand. There are some interesting teratological specimens from the glacial beds of the neighbourhood of Hamburg, one of which, a deformed *Galerites*, has a considerable influence on the true systematic position of that genus. The same drifts have yielded a good series from the Danien of Faxoe, while the large collection from the Upper Cretaceous of South Africa reminds the visitor of Prof. Gottsche's travels.

The contents of the Godeffroy Museum have already been removed to the new building, where the Director, Dr. Kraepelin, and his assistants, have temporarily arranged most of the zoological collections. The Echinoderms, including an extensive series from West Africa, have been classified by Dr. Pfeffer. Dr. Meiklesohn is engaged upon an index collection similar to that at the Natural History Museum, and several of his preparations are of especial interest to palæontologists.

### Berlin.

The "Museum fur Naturkunde" (at 43, Invalidenstrasse, just outside the Neue Thor) is that which will probably first attract the attention of the visitor. The Palæontological Department contains a fine series of type collections, many of which are associated with the work of the members of the staff. Thus it includes the collection of Prof. Dr. Beyrich, the present head of the Department, and many of the specimens described in the memoirs of Prof. Dr. Dames and Dr. E. Koken. Amongst other collections there are those of Leopold von Buch, and of Schlotheim; Fischer of Munich's great collection of Alpine fossils; many of Goldfuss's Corals and Bivalves and Mojsisovic's Triassic Cephalopoda; the best of the originals of Eck's *Trichasteropsis senfti* from the Saxon Muschelkalk, and half of the collection of Bundenbach Asteroidea, described by Herr Stürtz in his earlier monograph. The Museum seems also rich geographically; thus among the Echinozoa, in addition to the ordinary Continental localities, Greece, Persia, Egypt, Texas and others of the United States, Australia, etc., are all represented. There is too a good collection—as collections go—of the Echinoidea of the Alpine Trias, including a perfect specimen of the remarkable genus *Tiarechinus*; as the only hitherto recorded specimens are the two in Vienna, the opportunity for the examination of this was a very pleasant surprise. The greatest treasure of the Museum, it need hardly be remarked, is the second specimen of *Archæopteryx*.

Immediately adjoining the "Museum fur Naturkunde" is that of the "Geologische Landesanstalt und Bergakademie," in which is preserved a large stratigraphical series from Prussia and the Thuringian States. Amongst others it contains the collections of Koch and Dannenberg from the Devonian of the Rhine valley and the Tertiary of the Mainz basin: of Richter from the Silurian and Devonian of Thuringia: of Menzel from the Silesian Muschelkalk: of Schlömbach, Braun and Lasard from the Jura and Kreide of Bremen and

Hanover: of Becks from the Westphalian Kreide: of Zeigler from the Gault of Ahaus: of Speyer from the Hessian Tertiary: of Küsel from the Bukower Tertiary: of Meyn, Kloeden and Gumprecht from the North German "Flachlande": of Kovalevski from the Samland Bernstein; and finally Beinert's Carboniferous plants.

### Dresden.

In one corner of the Zwinger, in the picturesque old town of Dresden is the Mineralogical and Palæontological collection presided over by Prof. Dr. Geheimrath H. B. Geinitz and Dr. J. V. Deichmüller. The collections (open from 9 till 1) contain most of the types figured in the various monographs of the "Mittheilungen aus dem K. Mineralogischen Museum in Dresden," such as Prof. Geinitz's from the Saxon Dyas, or Dr. Deichmüller's insects from the Solenhofen stone. It also contains a choice series of fossils from the Cretaceous rocks of Saxony. Among the Echinoderms of this collection the gems are certainly the fine set of Asteroidea, the genera of which, however, require re-examination in the light of Mr. Sladen's recent *Challenger* Report; at present they are all included as *Stellaster*; but one at least (*S. albensis*, Gein.) must be included with *Nymphaster*.

At Dresden the geologist need not regret as much as at many towns the shortness of the hours during which the Museum is open. Though the palæontologist may feel little interest in the art treasures of the Zwinger, the geologist can profitably spend a few hours in the study of the landscapes of pre-Whistlerian 17th century impressionists; the unrivalled series of Ruysdael's and several of the rather rare works of his master Albert van Everdingen may be profitably compared with such masterpieces of 19th century realism as Papperitz's gneissose mountains (No. 2240) or Eug. Düncker's boulder bestrewn beach, or the roches moutonnées in Hemming von Kameke's Alpine landscape.

### Prag.

The scenery of Saxon Switzerland, with the deep valley of the Elbe bounded by flat topped hills often crowned with some picturesque old castle, forms a pleasant contrast to the sandy tracts of the North German plain. The geologist certainly should do this section of the journey by daylight; he can join with those whom a philanthropic age has sent to tenant the castles that surmount these historic hills in a philosophic contemplation of the precipitousness which cliffs of ordinary soft "kreide" can maintain when protected by a basalt cap.

At Prag the Museum is still in the old building in the Graben and the palæontological collection is displayed in a summer house in the garden. It will however be shortly removed to the colossal Bohemian National Museum now rapidly approaching completion at the end of the Wenzelplatz.

The principles upon which the new museum is to be arranged and the methods by which these are to be carried into effect are fully described in Dr. A. Fric's paper "Principien der Organisation der naturhistorischen Abtheilung des neuen Museums zu Prag."

The two most important collections in the Museum are those of Barrande and Sternberg. The latter is supplemented by a number of Feistmantel's types.

There is a small series of fossils from the minute patch of limestone that represents the Jurassic system in Bohemia. The Cretaceous collection is of course much more extensive; the originals of Dr. A. Fric's memoirs on the Crustacea of the Bohemian chalk are mostly preserved here, including his *Loricula pulchella*, var. *gigas*, the finest of the known fossil Cirripedia. The Museum also contains many of the types of Dr. Novak's admirable memoirs on the Bohemian Cretaceous Echinoidea and Bryozoa.

The second Museum at Prag is that of the German University (Naturwissenschaftliches Institut in Weinberg Gasse), of which the geological department is under the care of Prof. Dr. G. C. Laube. The collection, though not large, is one that well repays a visit, as it contains many types, as, e.g. of the Cretaceous Crustacea, which supplement the series in the National Museum. Most of the originals described in Laube and Bruder's work on the Ammonites of the Bohemian Kreide are to be seen here.

There is yet a third collection, of which Prof. Dr. O. Novak is the curator, at the Bohemian University.

## Vienna.

In the Austrian capital there are three geological collections each of the first importance, those of the Hof Museum, of the University, and of the k. k. Geologisches Reichsanstalt. The first of these is a palatial edifice in the Ringstrasse, and is probably the finest museum building on the Continent. The geological department is under the care of Dr. Fuchs, who has as his assistants Dr. E. Kittl and Dr. K. Wähner. The arrangement of the department is at once both instructive and interesting. The fossils are grouped stratigraphically in table cases: in wall cases around the rooms are collections of the rocks of the same formations, and above are views showing how they occur in the field. Thus the student of the fauna of any horizon can easily refer to the series of sedimentary rocks which illustrate the physical conditions of the period, while the pictures above show the beds in their typical development in the Austrian Empire. For example, above the Miocene rocks is a view of the great quarry of Margarethen in the Leithagebirge, and over the Jurassic is one of Csorsztyn in Galicia illustrating the Carpathian "Klippen."

The palæontological collection is not yet fully arranged, but by the courtesy of Dr. Fuchs it is all available for reference. It includes a fine series of Bohemian and Leithakalk fossils, and of those from the Tertiary of the Vienna Basin; many of the best of Laube's types from the St. Cassian Schichten are to be found here. The foreign collections are extremely rich, and they include those made during the voyage of the "Novara" and the types of Laube's Echinoids from the Murray River beds, the most important historical collection of Australian fossil Echinodermata. The plant collections are especially extensive. The department also includes a most

instructive collection illustrating dynamical geology, and in connection with this are views of glaciers, volcanoes, and other geological agents.

No reference to the Hof Museum would be complete which omitted to notice the meteorite collection, which is claimed to be the finest in the world. Its principal treasures are well known from the description of its curator, Dr. A. Brezina, in the Jahrbuch k. k. geol. Reichsanstalt for 1885. In the same room is the splendid petrographical collection arranged by Dr. Berwerth.

The University of Vienna is also on the Ring Strasse a few minutes' walk from the Hof Museum. Both the Geological and Palæontological Schools have valuable collections. The latter is of especial interest as having been made by the late Prof. Neumayr. The general geological collection is under the care of Prof. Dr. Suess, and it includes much new material, which is being described by Dr. A. Weithofer.

The faunas best represented—at least among the Echinodermata—are those of the Leithakalk and the North Italian Eocenes; several of the types of Bittner and Laube are to be found here.

The third collection in Vienna is that of the Geologisches Reichsanstalt in the Liechtenstein Palace in Razumoffsky Gasse. Here there is a very extensive Austrian collection, including many of the types of the species of the Director, Dr. Stur, and of Dr. Mojsisovics, Dr. Bittner and other members of the staff. The Triassic Cephalopoda, and Vicentin Echinoidea, and the collections from the Tertiaries of the Vienna basin, and of Galicia and Hungary, the Weisser Jura of Maehren, and Laube's types of Corals, Sponges, and Echinoderms, are especially worthy of notice. The type of Neumayr's *Tiarechinus* is one of the gems of the Museum. General geology is not neglected, and there is a good series of rocks and specimens illustrating the stratigraphy of the Austro-Hungarian Empire.

### Munich.

The Museum of the "Akademie der Wissenschaften" in Munich is probably that which will tempt the palæontologist to linger longest; for not only is the collection itself remarkably complete, but it includes a series of most important historical specimens, and by the courtesy of Prof. von Zittel it is available for study from 8 a.m. till 6 p.m. Foremost among the special collections is that of Baron Münster, including many of the specimens figured in Goldfuss and nearly all of those in the "Beiträge zur Palæontologie." Schafheutl's Bavarian collection, with all the Kressenberg types, also contains some very valuable material. Among the Echinodermata the following are especially worthy of notice: the Echinoidea from the Stramburger Schichten described by M. Cotteau: many of the best of the Asteroidea of Dr. E. Fraas' monograph: the *Echinopsis pusilla* redescribed by Dr. Ebert: a few of the types of Quenstedt's "Der Jura": of Prof. Dames' memoir on the Echinoidea of the Juras of the North-west of Germany, and most of the specimens from which were made the original illustrations in Prof. von Zittel's

great "Handbuch." The Solenhofen Echinoidea are represented by a series in the Haberlein collection and by the types of Bohm and Lorie's "Die Fauna des Kehlheimer Diceras Kalkes."

In other groups, the type series are not less important. Thus, in the Medusidæ, there are the specimens figured in Oppel's Beiträge, and in the memoirs of Häckel and von Ammon. The collection of Annelida include the most important of those described in Prof. Ehler's monograph, besides many types from the various general collections. The Crustacea are represented by an extensive series of important specimens: amongst others there are those described by Münster in his "Beiträge" and by Oppel in his "Mittheilungen," including some fine Isopoda and Cirripedia; also the Xiphosura used by Van der Hoeven in his "Recherches sur Limulus." The Sponge collection need hardly be mentioned, as Prof. von Zittel's work has for ever made it famous. The Brachiopoda and Mollusca include a miscellaneous series of types, as, *e.g.* many of those of Oppel's memoir "Ueber die Brachiopoden der unteren Lias," and of the various monographs of the "Geognostische Palæontologische Beiträge." The Cephalopoda include some remarkably fine specimens of the Belemnoteuthidæ and Chondrophora.

In addition to the general collection, which is classified zoologically, there is a supplementary stratigraphical series.

The Museum of the Bavarian Oberbergamt at 16, Ludwigstrasse, contains a collection illustrating the geology of that kingdom. The petrological collection is the most important feature in the Museum, containing as it does the rock specimens described by the Director, Prof. von Gümbel, in his "Die paläolithischen Eruptivgesteine des Fichtelgebirges," and his "Geognostische Beschreibung des Konigreichs Bayern."

### Stuttgart.

The Museum of the Würtemberg capital is especially famed for its Vertebrate treasures, and there is nothing among the Invertebrates that can equal in interest the great slab of *Aetosaurus*. Nevertheless it is well worthy a visit, as it contains an extensive collection from the Jurassic and Triassic rocks of the neighbourhood. Here are to be seen many of the types of Quenstedt's last work "Die Ammoniten des schwabischen Jura," besides a few of those of the "Petrefactenkunde Deutschlands," as, *e.g.* his interesting *Ophiura ventrocarinata*. Some of the Crustacea figured by Oppel, the finest of the *Plicatocrini* that illustrate Prof. von Zittel's memoir, Eck's *Trichasteropsis cilicia*, and Münster's *Asterias wissmanni*, are among the most important of the Invertebrates. There is also the extensive collection made by the Director, Prof. Fraas, in Syria and Egypt, and including the types of Prof. Dames' memoir on the Crustacea. African palæontology is represented by the collections made by Baron Ludwig, Dr. Krauss, and Dr. Holub.

### Tübingen.

On the brow of the central hill of Tübingen, where the steep slope that rises from the Neckar passes into the platform that bears

the Stiftkirche and commands a wide view over the Jurassic rocks of Suabia, is the Museum that will ever remain as a monument to the memory of the late Prof. von Quenstedt. The collection is a most interesting one, and even Baedeker remarks that it "deserves attention," though he only mentions the big 24-foot long Ichthyosaur, a fossil, however, which is dwarfed into insignificance by the clump of 70-foot Crinoids. It is unnecessary to refer to the special features of the Museum, as its contents may be summarized as the collection of Prof. Quenstedt, including the majority of the originals of the illustrations of his various works. To examine these every student of Jurassic palæontology must visit Tübingen, while the physical geologist cannot fail to learn much from a study of this, probably the best collection ever made to represent a fossil fauna.

### Heidelberg.

Though there is little or nothing among either the Invertebrates or Vertebrates that would induce a palæontologist to visit Heidelberg, he may well be excused if he turn aside to see the great petrographical collection of Prof. Rosenbusch. Certainly, no geologist who goes to Southern Germany should fail to examine it. The collection illustrating rock metamorphism and the origin of the crystalline schists is especially noteworthy; all phases of this controversy are illustrated, from the Norwegian mica-schists with Trilobites' tails, to the disputed Nufenen Schiefer and the "spotted rocks" of Scopi.

### Bonn.

Like so many of the German Museums, that of Bonn has recently changed its quarters. The collections have been moved from the Poppelsdorf to the University, and they were still in the packing cases at the time of my visit. Goldfuss's collection and the second half of Sturtz's first series of Bundenbach Echinoderms are preserved here.

The stock of Herr Sturtz (No. 2, Riessestrasse) always contains some novelties, and is well worthy of examination.

In conclusion, it remains to again express my warmest thanks to those whose unvarying courtesy and kindness rendered my visit to the Museums under their care as enjoyable as it was instructive.

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## IV.—On the Structure and Stratigraphical Relations of Rhobell Fawr.

By Grenville A. J. Cole, F.G.S., and
Thomas H. Holland, A.N.S.S., Berkeley Fellow of the Owens College.

IN a paper dealing with some phases of volcanic action in North Wales,[1] it was urged that contemporaneous eruptive rocks occurred on Cader Idris at lower horizons than the acknowledged base of the Arenig, although the actual vents from which they had arisen were lost and concealed under later accumulations. It was

[1] Cole and Jennings, "The Northern Slopes of Cader Idris," Q.J.G.S. vol. xlv. (1889), p. 437.

pointed out that the mass of Rhobell Fawr was of composite character, but was probably distinct from the series on Cader Idris. The fragmental character of much of its material having been recognized by the author of the Survey-Memoir, several theories are discussed in that work to account for its stratigraphical position.[1] In spite of the lack of detail, when compared with other areas, with which Rhobell Fawr has been represented on Sheet 75 S.E. of the Map of the Geological Survey, the ashes, "breccias," and other materials piled here upon the edges of the Lingula Flags are fully dealt with in the text of the Memoir, and we are left finally to select the most probable explanation of those put forward. Mr. Clifton Ward, quoted on p. 59, suggested that this centre of eruption broke out "after the close of the Tremadoc-slate period," the material thrown out being slightly different in character to that of the widely spread Arenig and Llandeilo series. Prof. Ramsay (on p. 74) seems also to hold this view, suggesting in addition that there is local unconformity between the Tremadoc and the Arenig series, whereby the "Arenig" volcanic rocks of Rhobell Fawr come to lie upon the denuded edges of the Lingula Flags. The remaining view hinted at in the Memoir is that the volcano of Rhobell Fawr is older than the Tremadoc slates. In the present paper, however, at the risk of multiplying explanations, we hope to bring forward evidence to show that it is in reality contemporaneous with the Tremadoc.

Mr. Clifton Ward, when mapping the Grit that has been regarded as the base of the Arenig in this area, records the discovery of "an oblong, angular block of grit" a little below the summit of Rhobell Fawr, "but no traces of the grit-bed were met with."[2] Whether or no we lay stress upon the continuity of a lithological horizon across a considerable area, there is no doubt that in this case gritty beds occur only a mile away on Allt Lŵyd, above the Tremadoc slates and below the Arenig volcanic series; hence a similar occurrence on Rhobell Fawr, as Mr. Ward perceived, would have a real and valuable bearing on the age of the underlying fragmental rocks.

Rhobell Fawr appears as a broad rugged moorland indented on the south-east side by a marked semicircular hollow, on the margin of which the two most distinctive summits rise. The more northern of these is Rhobell Fawr proper, reaching to a height of 2408 feet above the sea-level; the more southern is Moel Cors-y-garnedd, about 1650 feet high. On the northern slopes of the volcanic mass there are several picturesque little prominences, notably Rhobell-y-Big, some 1580 feet in height.

During a recent examination of the area, we have succeeded in finding bands of quartzose grit both on the summit of Rhobell Fawr and of Moel Cors-y-garnedd. In each case the bed is thin, measuring about one foot at the former point and three and a half inches at the latter.

On Moel Cors-y-garnedd this grit forms a patch underlying the

[1] A. C. Ramsay, "The Geology of North Wales," 2nd edition (1881), pp. 58 and 71.

[2] Ramsay, *op. cit.* p. 58.

rocks of the actual summit, which consist of light-coloured ash without distinct stratification. On its western side the grit is exposed along a north and south line for about 80 yards, and is seen to dip slightly to the east. Beneath it is an extremely characteristic slaty ash, dark and well bedded, with white or grey bands of coarser felspathic material. Intrusive dolerites come up from below into the series and locally affect its members.

The grit itself contains quartzite pebbles, sometimes three-quarters of an inch in diameter, together with numerous rounded fragments of black shale. Here and there rolled lumps of andesite occur, resembling those of the less basic tuffs of Rhobell Fawr. A thin parting of shale underlies the grit at places, dividing it from a layer of cemented sand. The shale-pebbles frequently lie with their longer diameters at a high angle to the planes of stratification, as though they had been rapidly hurried along by a current and banked up in the surrounding sand. The larger examples of these black lumps, which may have been only slightly consolidated when washed into the grit-bed, have developed a delicate concentric shell-structure by contraction, and often, in form and in the markings on their fractured surfaces, present a curious resemblance to Nummulites.

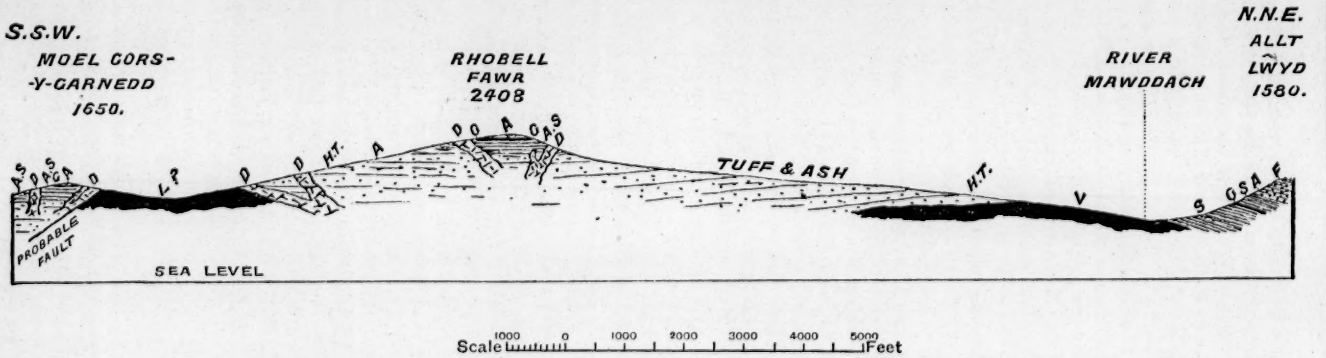
Lower down on Moel Cors-y-garnedd, in a hollow to the north-west of the summit, grit may be seen again, containing rather coarse pebbles of andesite; and on the bank rising to the east of this hollow there is a further exposure of grit in a bed having the thickness and characters of that occurring on the summit of Rhobell Fawr. The bed, which dips south-east, is exposed along a line running north-east and south-west. We have thus probably two distinct beds of grit on Moel Cors-y-garnedd, one of which resembles the grit of Rhobell Fawr, whilst both, curiously enough, coincide in thickness and relations with the two bands of grit which we shall mention as occurring on Allt Lŵyd.

The summit of Rhobell Fawr is similarly encircled by exposures of quartzose grit, which correspond in character with the lower bed on Moel Cors-y-garnedd. This grit is best seen to the north-west of the 2408 point, where it has an easterly dip. The dip, however, varies, and, by crossing the adjacent boundary-wall, several outlying exposures are encountered, much disturbed by the invading dolerites. On the south-west of the summit the grit is replaced by a sandy ash; and it graduates down into a similar bed along its best defined outcrop. Below it are the characteristic slaty ashes, precisely as at Moel Cors-y-garnedd; while above are bedded but coarser ashes. Hence the two conspicuous crests of the denuded volcanic area appear to owe their origin to the presence of these relics of a once continuous gritty layer. The metamorphic action of the intruding dolerites may have given the bed at both points local powers of resistance.

In order to compare the grits of Rhobell Fawr with those recognized as of Arenig age, we examined the steep front of Allt Lŵyd ("Rallt Llwyd" of the one-inch map), which rises close at hand, facing the volcanic area. The typical grey quartz-grit occurs here

SECTION ACROSS RHOBELL FAWR

FROM ALLT LŴYD TO MOEL CORS-Y-GARNEDD, N. OF DOLGELLEY, N. WALES.




G. Bands of Grit.
S. Slate.
A.S. Ashy Slate.
A. Ash.
H.T. Tuff with Hornblende crystals.
L. Lingula Flag series.
D. Dolerite.
F. "Felstone" series of Arenig age.

about 250 feet above the Afon Mawddach, or 1200 feet above the sea. The beds dip from 25° to 30° to the north-east, and, if continued across the valley, would rise easily towards the crest of Rhobell Fawr. Below the grit is a series of imperfect slates, regarded by the Survey as Tremadoc; while beneath these, on the opposing slope, undoubted Lingula Flags occur. Above the main grit-band come about seven feet of slates; then a thin upper seam of grit. Both these beds, as on Moel Cors-y-garnedd, contain black argillaceous pebbles as well as quartz. Higher up follow more slates, and then finely-bedded ashes like those associated with the grit on Rhobell Fawr. Lastly we have the well-marked Arenig volcanic series, with its grey massive "felstones" or eurites, forming the dip-slope of Allt Lŵyd and the summit-cliff of Ddualt, the latter lying immediately to the south.

We have found a pebble of pisolitic iron-ore high upon Allt Lŵyd, and the bed occurs *in situ* below the eurite on the hill east of Llanfachreth.

The base of the ashes and agglomerates of Rhobell Fawr admittedly rests upon Lingula Flags. The slaty beds of this series, with the peculiar black streak mentioned by Belt as characteristic of his "Dolgelly Group," may be traced all round the area, and notably upon the north near Rhobell-y-Big. In the beautiful little gorge of the Afon Geirw, the igneous rocks are distinctly intrusive, and the Lingula series is considerably contorted and crumpled; but in the moor east of Rhobell-y-Big the hornblendic ashes that constitute the remarkable basement-layers of the volcano can be seen in direct contact with slates containing *Orthis lenticularis* and numerous fragmentary remains of small Trilobites. Careful search in this district should reveal many of the fossil forms already known from Moel Hafod-Owen.

This junction with the volcanic series is well exposed in the little stream-cut, about 1300 feet above the sea, descending to the Mawddach at Dol-y-cynafon. The great mass of hornblendic ash and tuff rises above, as is clearly shown at Graig Fach some two miles further to the south. As Professor Ramsay has pointed out, there is no evidence to connect the volcanic series with the Lingula Flags. It occurs upon the highest members of that series, without the intervention of Tremadoc beds; but at the same time it differs in lithological characters from the adjacent volcanic products that undoubtedly overlie the Arenig grit.

The apparent thinness of the Tremadoc Slates in this area has caused some trouble to stratigraphers; but, supposing a fault to occur along the foot of Allt Lŵyd and of Ddualt, this only serves to increase the difference of level and of relations between the series of Rhobell Fawr and that of the Arenig "felstones." The position of the grit-beds on Rhobell Fawr seems to greatly strengthen our contention, viz. that this mass represents a volcanic outbreak occurring between the deposition of the latest Lingula Flags and the Arenig grit, and consequently of Tremadoc age.

The earliest outbursts were doubtless accompanied by considerable

movement of the sea-floor, allowing even of local denudation; while hollows may have been formed by the explosive action, though there is a marked absence of the tuffs with slate-fragments that are so conspicuous on the slopes of Cader Idris.

The coarse hornblende-ash, with its handsome crystals, a rock perhaps unique in Wales, passes into more fine-grained types as the summit of the hill is neared. At the close of activity we find, both on Rhobell Fawr and Moel Cors-y-garnedd, a return to normal sedimentation, the formation of shaly layers, and the incoming of the beds of grit. The latter were deposited by waters flowing not only over ancient quartzites, but over andesitic cones, which had at one time risen well above the sea.

To the east, in the area of Allt Lŵyd and Ddualt, ordinary sediments were contemporaneously formed; and when the volcanic activity diminished, and the vast mass of erupted matter sank into the shattered and yielding Lingula Flags through which it had been projected, a common undisturbed sea-floor was re-established, and the sandy layers were deposited over all alike. The intrusive dolerites, which, with the other rocks, we hope to subject to closer petrological examination, may or may not prove to be connected with the fragmental deposits of Rhobell Fawr. In any case we cannot but regard this volcano as commencing in Tremadoc times, and as a precursor of the great Ordovician eruptions; and the existence of such sporadic outbursts must be taken into account as a disturbing cause when we seek to correlate the strata below the Middle or basement Arenig of North Wales with those of other areas.

We append a section, in the preparation of which we have been greatly aided by the new Ordnance maps on the scale of six inches to the mile. Considering the absence of the hornblendic tuffs on the east of Moel Cors-y-garnedd, and the close resemblance of the beds beneath the grit to those on the summit of Rhobell Fawr, we have represented the great mass of the tuffs at the former point as cut out by an oblique fault, which would account for the low position of the grit-series and its proximity to the black Lingula Flags. The vertical scale of the section is the same as the horizontal, so that distortion of dip or of the relations of the several exposures of the grit is, we trust, avoided.

During our examination of the area of Rhobell Fawr, we have been frequently in communication with Mr. G. J. Williams, F.G.S., who has remarked, among other notes, upon the similarity of a specimen of the grit of Moel Cors-y-garnedd and the typical Garth grit of the Ffestiniog area.

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## V.—On the Occurrence of *Lemmings* and other Rodents in the Brick-Earth of the Thames Valley.

By E. T. Newton, F.G.S., F.Z.S.

NOTWITHSTANDING the large number of Mammalian remains which have been found in the Brick-Earth of the Thames Valley, they have for the most part been portions of the larger forms, and very few examples of the smaller Mammals have hitherto

been discovered. Professor W. Boyd Dawkins and Mr. W. A. Sanford (Brit. Pleist. Mam. Pal. Soc. vol. for 1864, p. xxxvi, 1866) have noticed the occurrence of *Arvicola amphibia* in the Pleistocene of Ilford, Crayford, and Erith; while from the last-named locality Mr. R. W. Cheadle (Proc. W. London Sci. Assoc. vol. i. p. 71, 1876) recorded the remains of *Spermophilus*, which Mr. Lydekker has more recently (Cat. Foss. Mam. Brit. Mus. part i. 1885, p. 212) referred to Falconer's species *S. erythrogenoides*.

Several species of small Rodents have been discovered in Pleistocene deposits in other parts of England (see Sanford, Quart. Journ. Geol. Soc. vol. xxvi. p. 124, 1869, and Blackmore and Alston, Proc. Zool. Soc. 1874, p. 460), and it seemed likely that they would be found also in similar deposits of the Thames Valley. As no such specimens were to be found in the British Museum, and only one was preserved in the Museum of Practical Geology, I applied to several friends who had made collections from these deposits; but the result was far from satisfactory. However, Mr. Spurrell and Mr. Cheadle each possessed, in addition to the remains of *Spermophilus*, some Arvicoline bones, teeth and jaws, and I am under obligation to both my friends for readily placing their specimens in my hands for determination, thus enabling me to record from the Brick-Earth of the Crayford district two species of *Myodes* (Lemmings) and an Arvicola (Vole), not hitherto known to occur in that district.

The teeth of these Rodents are very characteristic, and the species may therefore be determined with certainty, but the limb-bones cannot so easily be correlated with the teeth.

*Microtus* (*Arvicola*) *amphibius*, Linn., sp.

The only specimen from the Brick-Earth of the Thames Valley which I can with certainty refer to this species is a portion of a lower jaw, from Ilford, in the Cotton Collection, preserved in the Museum of Practical Geology. All the remains of Arvicolidæ from Crayford and Erith, which I have seen, are referable to one or other of the species noticed below.

*Microtus* (*Arvicola*) *ratticeps*, Key and Bl., sp.

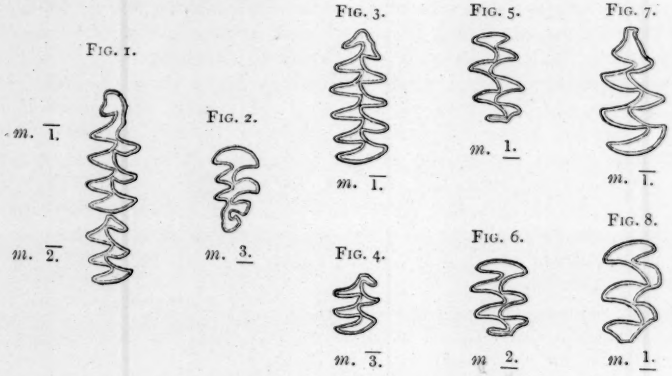
A right ramus of a lower jaw, with two grinders (Fig. 1) in place, together with isolated teeth, from Crayford, in Mr. Cheadle's Collection (now preserved in the Museum of Practical Geology), and three lower jaw rami and several teeth in Mr. Spurrell's Collection, from Erith, are referred to *Microtus ratticeps*.

The most characteristic tooth of this species is the anterior grinder of the lower jaw (Fig. 1, *m* 1), which has five angles on the inner side and three on the outer side, the two anterior and outer columns having coalesced to form one cement space with a nearly flat outer wall. There are differences to be observed, among the specimens from the Thames Valley, in the form of this anterior and outer column, the example figured being rather larger than some of the others, and more nearly resembles the figure given by Messrs.

Blackmore and Alston (*loc. cit.* p. 465), who call attention to similar variation which they have noticed in this species. The second lower grinder (Fig. 1, *m* 2) has three inner and three outer angles, but this tooth is not characteristic. There are several examples of the peculiar last upper grinder of this species (Fig. 2), which has four inner and three outer angles, with the hinder end of the tooth curved and hook-like.

The occurrence of this species in the Thames Valley has already been noticed in Mr. Whitaker's Geology of London and Parts of the Thames Valley (Mem. Geol. Survey, p. 336, 1890).

At the present day *Arvicola ratticeps* is found in the more northern parts of Europe and Asia.




EXPLANATION OF FIGURES.

Patterns of grinding surfaces of teeth of Arvicolidæ from the Brick-Earth of Crayford and Erith.

Fig. 1. *Microtus* (*Arvicola*) *ratticeps*, right lower molars 1 and 2.
„ 2. Ditto, right upper molar 3.
„ 3. *Myodes torquatus*, right lower molar 1.
„ 4. Ditto, right lower molar 3.
„ 5. Ditto, right upper molar 1.
„ 6. Ditto, right upper molar 2.
„ 7. *Myodes lemmus*, right lower molar 1.
„ 8. Ditto, right upper molar 1.

All the figures five times natural size.

### *Myodes torquatus*, Desm.

Mr. Spurrell possesses a single example of this species from Erith, and the specimen consists of a portion of a right mandibular ramus with the first and third molars complete and *in situ*; but only a fragment of the second tooth remains. Embedded in the same piece of matrix, and in natural relation to the lower jaw, is a portion of the right maxilla with the first and second grinders in place, but the third, hinder molar is wanting. The camera-lucida drawings of the patterns of these teeth (Figs. 3, 4) will be found to agree so exactly with those of *Myodes torquatus* as to leave no doubt as to their specific identity.

The anterior lower grinder has six inner and five outer angles, while the last lower grinder (Fig. 4) has three inner and three outer angles, with five cement spaces, the anterior outer space being distinctly smaller than the others. The anterior upper grinder (Fig. 5) has four inner and four outer angles, with seven cement spaces, the hindermost of the inner spaces being rudimentary. The second upper grinder (Fig. 6) has four inner and three outer angles with six cement spaces, the hindermost of the inner spaces being again rudimentary.

There is in the Museum of Practical Geology another specimen, referable to this species, from the Brick-Earth of Murston, near Sittingbourne, Kent. It comprises parts of both upper and lower jaws, very much crushed, but with the upper incisors, and, fortunately, one of the anterior lower grinders preserved. The pattern of the last-named tooth, with its six inner and five outer angles, leaves no doubt as to its belonging to *Myodes torquatus*.

At the present day *Myodes torquatus* has a circumpolar distribution; but is rare in Greenland, and is said not to occur in Russian Lapland.

*Myodes lemmus*, Linn.

Another specimen from Erith, in Mr. Spurrell's Collection, is to be referred to *Myodes lemmus*; it is a part of a lower jaw embedded in matrix, with the two incisors and the right and left anterior grinders in place; there are also fragments of the upper jaw including the right and left anterior grinders.

The lower front grinder (Fig. 7) is characterized by four inner and three outer angles, with five cement spaces; while the upper front grinder (Fig. 8) has three inner and three outer angles, with five cement spaces.

*Myodes lemmus* is living at the present day; but is restricted to Scandinavia and Russian Lapland.

The Rodents now known to occur in the Brick-Earth of the Thames Valley are:—*Castor fiber*, Linn.; *Spermophilus erythrogenoides*, Falc.; *Microtus* (*Arvicola*) *amphibius*, Linn.; *Microtus* (*Arvicola*) *ratticeps*, Key. and Bl.; *Myodes torquatus*, Desm.; and *M. lemmus*, Linn.

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## VI.—Vertebrate Palæontology in some American and Canadian Museums.

By A. Smith Woodward, F.G.S., F.Z.S.,
of the British Museum (Natural History).

(*Concluded from the September Number, page 395.*)

### Washington.

The collection of Fossil Vertebrata in the National Museum at Washington is at present insignificant; and the only type-specimens observed by the writer are the fish-remains described by Prof. Leidy under the names of *Clupea humilis*, *Cladocyclus occidentalis*, *Phareodus acutus*, and *Lepidosteus simplex*, besides some fragmentary

specimens from the Hamilton Group made known by Prof. J. M. Clarke in the Bull. U. S. Geol. Survey, No. 16 (1885). The palæontologist interested in the lower vertebrates, however, finds much to occupy him in the collection of recent fish skeletons made by Prof. Theodore Gill, who has contributed perhaps more than any other ichthyologist to our knowledge of those parts with which the palæontologist is alone able to deal. At the time of the writer's visit, Prof. Gill was occupied with an investigation of the skeletal anatomy of the eels; and a large number of beautiful drawings of the cranial osteology of various great groups of bony fishes, as yet in the Professor's portfolio, are intended for the basis of a forthcoming general work, to which all who are interested in palæichthyology will anxiously look forward.

ROCHESTER, N.Y.

No European regards a tour on the American Continent complete without at least a brief visit to the remarkable cataract of Niagara, whether regarded merely as a scene or as a noteworthy geological phenomenon; and the palæontologist feels an additional attraction in that direction from the close proximity of Rochester, where Prof. Henry A. Ward has his well-known emporium of recent and fossil zoological specimens, rocks, and minerals. "This is not a Museum, but a working establishment, where all are very busy!"—according to the printed notice that first meets the visitor's eye; but there is always a welcome for the Naturalist, and the specimens are far more carefully displayed and more beautifully kept than in many Museums the writer has had the privilege of visiting. In addition to the ordinary routine of business, Prof. Ward is at present engaged upon an unique collection of the skeletons of marine Invertebrata; while his geological partner, Mr. E. E. Howell, is equally absorbed in bringing together an extensive series of Meteorites. The Professor's visit to South America last year resulted in the discovery of several skeletons of the large extinct Edentata, which are now being mounted for the Agassiz Museum at Cambridge; and the large collection of material in the palæontological galleries comprises much that is as yet quite unrepresented in European Museums. Numerous Cretaceous Fishes and Mosasaurians from Kansas, a large series of the well-known fishes of the Green River Shales, and several Chelonian and Mammalian fossils from the Tertiaries of the West, were among the principal Vertebrates the writer observed.

TORONTO.

Fossil Vertebrata do not appear to have been much represented in the Museum of the Toronto University. It may, however, be remarked that all the palæontological specimens were in the main building, of which the greater part was destroyed by last year's disastrous fire. The collection will thus require complete renewal.

OTTAWA.

In the Canadian capital, closely adjoining the Government grounds, is the small, neatly arranged Museum of the Geological Survey,

occupying the same building as the offices of the Surveyors. One comparatively large gallery is devoted to Canadian fossils, arranged in stratigraphical order; and here are conveniently displayed all the type-specimens described in the publications of the Survey. Among lower Vertebrates the fine collection of Devonian Fishes from Scaumenac Bay, made known by Mr. J. F. Whiteaves, F.G.S., is most conspicuous; and in the total absence of all European material for comparison, one cannot but be struck with the success with which the specimens have been determined and interpreted. Mr. Whiteaves' published figures are, for the most part, slightly restored outlines; but the specimens are all in an exquisite state of preservation, while many minute points in their skeletal anatomy (*e.g.* the "lid" of *Bothriolepis*) have only been exposed by a careful removal of the adhering matrix. Several small Palæoniscid fishes from the Lower Carboniferous of New Brunswick are also exhibited; and among the miscellaneous collections in cabinets is a large series of fish-fragments from the Coal-measures of Cape Breton, closely resembling a collection that might be obtained from the shales of almost any British Coal-field. Among recent acquisitions is an interesting small collection of Chimæroid teeth and other fish-remains from a newly-discovered Devonian horizon in Winnipeg, which will shortly be described by Mr. Whiteaves. One case in the public gallery is occupied with numerous fragments of Tertiary Mammalia, also lately received from the N.W. Territories; and these will form the subject of a forthcoming memoir by Prof. E. D. Cope, considerably extending the known range of some of the genera already described from more southern areas. The walls of the Museum are occupied with maps, sections, proof-plates, and several slabs of rock, the latter including among others the well-known footprints of *Sauropus*, from the Millstone Grit of Nova Scotia, described by Sir J. William Dawson.

### Montreal.

There are two interesting palæontological collections in Montreal —that of the Natural History Society, and that founded by Sir J. William Dawson, F.R.S., in the Peter Redpath Museum of Mc Gill College. The latter, however, alone comprises any Vertebrates of importance. Here are preserved the remarkable skeletons of Labyrinthodonts discovered by Sir William Dawson in the Carboniferous tree-stumps of the South Joggins; and here, too, are nearly all the fish-remains described or noticed in the "Acadian Geology." The Labyrinthodont fossils are most difficult of determination from the imperfect and scattered nature of the bones; and many of the structures most carefully and beautifully figured in Sir William Dawson's well-known memoirs can only be observed after the closest scrutiny. Among the fish-remains, the type of *Palæoniscus modulus* appears to the present writer to belong to the Scottish Lower Carboniferous genus *Canobius*, as defined by the latest researches; while the supposed remains of *Rhizodus* would in Britain be assigned to its closely related genus *Strepsodus*. Numerous fish-fragments from the Coal-measures of Nova Scotia indicate the occurrence of

*Acanthodes*, *Rhizodopsis*, *Megalichthys*, *Cœlacanthus*, and *Platysomus*; and among Devonian fishes, there is the unique type-specimen of *Cephalaspis Dawsoni* from Gaspé. Of recently determined acquisitions, the most interesting, perhaps, is a small *Cottus* from the Pleistocene nodule bed of Green's Creek, near Ottawa, described by Sir William Dawson in vol. iv. No. 2, of the "Canadian Record of Science." All the more important of these fossils are beautifully displayed, with complete labels, in small exhibition cases; and the collection is arranged in stratigraphical order on the first floor of the Museum, with the zoological collection in an encircling gallery immediately above.

### Quebec.

There is a small Museum in the Laval University, Quebec, under the care of the Abbé Laflamme; but the palæontological collection is insignificant, and the only items of special interest are the relics of the old Huron Indians.

### Boston and Cambridge.

The fine Museum of the Boston Society of Natural History comprises a good general European collection of fossils in addition to those of America; but the only Vertebrates of special interest are some well-preserved examples of the Lower Carboniferous Palæoniscid fishes from New Brunswick, and a few representatives of *Ischypterus* and *Dictyopyge* from the black Triassic shales of Connecticut.

In the adjoining University city of Cambridge, however, there is a most extensive collection of fossil Vertebrata in the Agassiz Museum of Comparative Zoology. One of the most striking features of the public galleries in this Museum is the manner in which merely a selection of the more instructive types is exhibited, without any of the overcrowding and bewildering array that characterizes most institutions of a similar nature. The majority of the remains of extinct Vertebrata are thus placed in one of the capacious store-rooms; and the collection has accumulated to such an extent that it has been necessary to stow away the specimens, in most cases, upon shelves and in drawers without any definite arrangement. The Mammalia form the only group that has hitherto been investigated in detail, these remains being described by Professors Scott and Osborn, of Princeton; but the fossil Reptiles occupy many cabinets, and the fossil Fishes, to which the writer devoted most of his attention, by kind permission of Prof. A. Agassiz, form a still more extensive series, representing both the Old World and the New. A large number of Cretaceous fish-remains from Kansas are referable to genera and species described by Prof. Cope; and several fishes from the Coal-measures of Ohio evidently represent forms made known in the works of Prof. Newberry. The Wachsmuth collection of American Lower Carboniferous Selachian teeth is also here; while a number of remains of the huge *Dinichthys*, discovered by Mr. Jay Terrell in Ohio, and lately studied by Prof. Newberry, are rivalled only by those in the Museum of Columbia College, New

York. Among miscellaneous European fossils is the type-specimen of *Semionotus Nilssoni*, Ag., from Sweden; and most British and Continental horizons are well represented by typical species. From the Lower Carboniferous of Scotland there is the fine collection of Mr. Thomas Stock; and from the Coal-measures of Yorkshire is a small series collected by Mr. Percy Sladen. One of the Haeberlein Collections furnishes a great number of beautiful fishes from the Bavarian Lithographic Stone; and there are many drawers of Tertiary fishes obtained from various sources. The most precious of all European collections, however, is that of Schultze from the Devonian of the Eifel, which is in many respects unique. In this are preserved the type-specimens of H. von Meyer's *Physichthys Hoeninghausi*, proving that that supposed genus and species is founded upon remains of three distinct genera (*Macropetalichthys*, *Pterichthys*, and *Ptyctodus*); there are also many examples of Schlüter's *Ceraspis*, which are more suggestive of an ally of *Asterolepis* than of a Pteraspidian; and a number of sigmoidal detached teeth are indistinguishable from those of the "intermandibular arch" of *Onychodus*. In the basement of the Museum, Mr. Samuel Garman has the large collection of recent fishes, amphibians, and reptiles under his charge; and here is the original example of the antique Shark, *Chlamydoselache*, described in his well-known memoir.

### Yale University, New Haven.

Of the Peabody Museum in Yale University only one wing is as yet erected, and the enormous collections are thus crowded together in an almost inaccessible manner. The Palæontological Department, under the direction of Prof. Marsh, occupies by far the greatest space; for here is preserved not only the well-known collection of the Professor himself, but also that of the present U.S. Geological Survey made under his direction. The former is destined to remain in its present "location," while the latter will be forwarded in instalments to the National Museum, Washington, as the various groups are investigated and described.

Only one public gallery is devoted to the exhibition of the American extinct Vertebrata; and, as in the case of the Cambridge Museum, merely a few prominent types of each great group are selected for representation. The greater portion of the skeleton of a finely-preserved *Mastodon* occupies the first wall-case on the Mammalian side of the gallery; and this is followed by tolerably complete series of bones of various genera and species of Brontotheriidæ and Dinocerata. The skulls and examples of the dentition are especially fine, and all the more massive specimens are mounted upon plaster bases for support. A few small feet illustrate some stages in the history of the Equidæ, though the series is not so complete as an ordinary visitor would desire; and another table-case contains the type-collection of the now well-known birds with teeth, from the Kansas Chalk. Immediately opposite the entrance, spread out upon the floor, are some of the limb-bones, the sacrum, and caudal vertebræ, of the huge *Brontosaurus*, of whose dimensions the reduced

published figures can give no adequate idea. The remainder of the bones are placed in one of the store-rooms below, and it is not unlikely that a model of the complete skeleton will be prepared and mounted for the forthcoming World's Fair at Chicago. Many other portions of Dinosaurs, including *Atlantosaurus*, *Morosaurus*, *Stegosaurus*, etc., are arranged in and upon the adjoining wall-cases; and a typical series of the enormous dermal plates and spines of *Stegosaurus* is placed on plaster blocks in one of the table-cases. A large slab from the Cretaceous of Kansas displays the skeleton of a Mosasaurian Reptile in a condition such as is unknown among its European congeners; and a single table-case is devoted to a large series of Teleostean fishes from the Green River Shales of Wyoming.

The nature of the contents of the extensive store-rooms is so well known from the published descriptions and figures of Prof. Marsh, that it is unnecessary to attempt any enumeration. It is only to be regretted that so great a want of space should prevent the materials being arranged in a more accessible manner. All the smaller specimens are contained in wooden trays, piled up from the floor to the roof in long rows, though all carefully labelled according to the Museum Register; while the larger fossils are placed on the floors and shelves wherever there happens to be an available corner. The latest arrivals, as yet untouched, are also there, wrapped up like mummies in encircling strips of linen and old garments. Other specimens are being extricated from the matrix by the skilful masons—the huge horned Dinosaur, with a head six feet long, undergoing this operation at the time of the writer's visit. The artist is at work in another room, where many of his finest drawings adorn the walls; and at present the sifting of fine Laramie material is also in progress, for the recovery of the Mammalian teeth, of which many have been made known by the Professor. Among lower Vertebrates, there is the Redfield Collection of Triassic Fishes; and numerous Cretaceous and Tertiary Fish-remains, as yet almost untouched, are scattered through the trays more especially devoted to Reptilia and Mammalia.

In this Museum, as at Philadelphia, a series of fragments of the Wealden Dinosaurs from Sussex bears witness to the generosity of Dr. Mantell at the time when such remains excited the wonder of naturalists everywhere and were still unknown in the New World; and if our American fellow-workers, out of their present riches, reciprocated this gift in proportion, British palæontologists would already have a fine series of actual specimens for comparison, instead of being compelled to rely entirely upon published descriptions, figures, or casts.

In conclusion, the writer would tender his best thanks to all whose cordial receptions everywhere added so much to the enjoyment of his tour. Even under the most unfavourable circumstances, every facility for study was invariably granted; and where such large collections have accumulated in so short a space of time the difficulty of convenient arrangement is in nearly all cases considerable.

## VII.—On a New Form of Spiral in *Spirifera glabra*.

By the Rev. Norman Glass.

In Davidson's Monograph of the British Carboniferous Brachiopoda (1857), p. 60, he gives the following specific characters of *Spirifera glabra*:—"Very variable in shape and proportions; transversely oval, rarely as long or longer than wide. Valves almost equally convex, with a mesial elevation or fold in the dorsal, and a sinus in the ventral valve. Hinge-line much shorter than the greatest width of the shell; cardinal angles rounded; beaks rather approximate, that of the larger or ventral valve prominent, incurved, and of moderate dimensions. A hinge-area in the dorsal valve, that of the ventral one triangular and of moderate dimensions, with its lateral margins more or less sharply defined; fissure partially covered by a pseudo-deltidium. The mesial fold in the dorsal valve is either slightly and evenly convex, rising gradually from the lateral portions of the valve, or abruptly elevated, with a longitudinal depression along its middle, which is also at times reproduced in the sinus of the ventral one. The spiral appendages are large, and occupy the greater portion of the interior of the shell. Surface of valves in general smooth, but sometimes a few obscure rounded ribs may be observed on their lateral portions."

In a note appended to the above Davidson says:—"I have already had occasion to remark, at p. 81 of my General Introduction, that in p. 139 of his 'Synopsis,' Professor McCoy has described and represented the spiral appendages of *Spirifera* (*Martinia*) *glabra* so small as only to occupy the rostral half of the shell, but this has been proved incorrect; for all specimens obtained in which the spirals were preserved, have shown them to be as large as in any other species of the genus."

With the view of finally deciding this matter of dispute, Davidson, previous to his publication of the Carboniferous Supplement in 1880, desired me to obtain specimens of *Sp. glabra* in order to develop the spirals. I was soon enabled to develop specimens of this species showing the spirals occupying their usual space in the shell, but the specimens thus successfully worked out were comparatively small, and Davidson urgently pressed me if possible to work out some larger specimens. Probably many of your readers are acquainted with the farmhouse and the fields adjoining, which divide the top of the Winnats near Castleton, in Derbyshire, from the high road to Chapel-en-le-Frith. This place is vividly impressed upon my memory in connection with my search for large specimens of *Sp. glabra*—for it was here on a dark winter's night after one of my endeavours that I fell into a snowdrift, and had a long and weary search for the high road, which was so near, but which seemed to me so far. However, my journey, as it proved, was not unsuccessful; for I had a specimen in my pocket which when developed greatly pleased my friend Dr. Davidson. It was the largest specimen of *Sp. glabra* I had worked out up to that time, and it is represented

in Davidson's Carboniferous Supplement, pl. xxxii. fig. 4. This specimen shows the spirals nearly filling the shell, and it was regarded by Davidson as completely disposing of McCoy's attempt to erect *Sp. glabra* into a new genus.

But in June, 1890, I obtained, during a visit to Castleton, a larger specimen of *Sp. glabra* than that just referred to, and of a somewhat different shape, being longer in proportion to its width. A portion of one side of this specimen had been broken away, but in the other portion I succeeded in working out one of the spirals *in situ*, and a small portion of the other spiral, showing, however, its attachment and direction. The shape of the spiral in the new specimen, and the space which it occupies in the shell, is shown in the accompanying sketch.

*Spirifera glabra*, Martin. Half natural size.

The spiral commences with two or three very large coils which extend nearly the whole length of the interior of the dorsal valve. These large coils are succeeded by others of about half the diameter, which continue with hardly any diminution of size nearly to the end of the spiral. That part of the spiral which is formed by the smaller coils projects outwards towards the lateral margins of the shell from the posterior half of the larger coils—the posterior border of the whole of the spiral being thus nearly straight, and lying close under the hinge-line of the shell. This shape of the spiral, so far as its anterior border is concerned, is quite unique. Out of the thousands of spirals I have seen during my researches amongst British and foreign specimens, I have not met with one of the same shape. It has been abundantly proved by recent investigation in the fossil Brachiopoda that in the various specimens belonging to the same species there is considerable modification as to the shape of the spirals, and that this modification seems to be governed in the majority of instances by the variation in the size and shape of the shell (see the descriptions and figures of my preparations of *Spirifera striata* and *Atrypa reticularis* in Davidson's Carboniferous and Silurian Supplements)—so that there is nothing abnormal in the occurrence of differently shaped spirals in a newly developed specimen of *Sp. glabra*.

This larger specimen of *Sp. glabra* which I have now developed would have greatly interested Dr. Davidson because showing how the mistake of McCoy might naturally have arisen. As the first two or three coils of each spiral are prolonged nearly to the anterior margin of the shell, the spirals cannot properly be described as being "so small as only to occupy the rostral half of the shell"; whilst on the other hand it is evident that through the greater part of each spiral being close to the posterior border of the dorsal valve, there remains a large portion of space in the shell which the spirals do not occupy. If, therefore, in the specimen seen by McCoy, the prolongation of the first two or three coils of each spiral towards

the anterior margin of the shell, was either not exposed, or broken away at the time of deposition, the conclusion at which he arrived was a very natural one, though not in accordance with the results of further investigation.

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## VIII.—Notes on some Observed Rates of Weathering of Limestones.

By J. G. Goodchild, F.G.S., of H.M. Geol. Survey,
Lecturer on Geology at the Heriot Watt College.

In the Geol. Mag. for July, 1875, p. 326, the writer of the present note gave some data bearing upon the rate of weathering of certain limestones of the Lower Carboniferous Series, deduced from the observed extent of waste that had affected some dated tombstones in Kirkby Stephen Churchyard. The series of observations of which that formed a part were suggested several years previously by the fact that many of the rough blocks of limestone used for walling in that neighbourhood had evidently suffered considerable waste since the erection of the walls, and this especially on the upper and outer surfaces of the stones referred to. In a few of these cases (as well as in many other cases observed since) it was perfectly evident that, since the coping stones had been placed in their present positions, the waste of the limestone by atmospheric causes had proceeded to at least as much as a quarter of an inch. This was evident from the fact that thin, delicate, fragments of Corals, Brachiopods, Encrinites, etc., were left standing out in sharp relief to that extent above the general surface of the adjoining limestone matrix. There could be no doubt about the fact itself, or about its significance; but many inquiries failed to bring to light any reliable information regarding the precise date when the stones were first quarried. For aught we could say to the contrary, any one, or all, of the stones might have been employed for building purposes for hundreds of years previously; although that was hardly likely.

Similar phenomena were observed along the walls of the North Western Railway between Teba and Shap; but regarding the earlier history of these no reliable information could be obtained.

With the tombstones above referred to the case was different. Here we had stones that had been carved out of solid, unweathered limestone at a given date recorded upon the tombstone itself, and side by side with the date was given, by the hand of Nature, a fairly exact record of the amount of limestone that had been carried away in solution from the general surface of each of the tombstones in question. The mean of several observations gave as the rate of solution about one inch in five hundred years (Geol. Mag. 1875, p. 326). These observations were made upon tombstones standing erect, and therefore in the least favourable position for the kind of erosion under notice. Where similar stones were lying flat, waste by atmospheric causes almost certainly proceeded at a higher rate: but no dated tombstones in this position could then be found. In the estimate just given no account was taken of the fact that other

planes of easy solution were evidently in process of development. Some of these were following the original planes of deposition of the rock; others tended to work in along the bate, or those obscure planes of separation along which direction, as masons know, the rock will dress more readily than along others. Other planes again, artificially induced, were being etched parallel to the dressed surface, as Prof. Judd had shown to be the case with the worked flints employed for outdoor masonry. Altogether, a careful study of the phenomena of erosion presented by these dated tombstones, pointed to the conclusion that the rate of waste now in progress will, in a few years, be very greatly accelerated by the multiplication of the surfaces presented to the denuding agents. We might, therefore, safely assign to this rock a rate of destruction treble or quadruple that given in the estimate above. Weathering soon reveals the existence of the 'bate' in limestones, and detaches flake after flake, parallel to the joint planes, with comparative rapidity; almost as if the bate or grain of the rock represented some kind of cleavage affecting the whole mass of the limestone. On the vertical face of limestone scars, or in the same position in limestone waterfalls, it is very evident that the chief waste of the rock is effected by this constant flaking off of thin slices of weathered rock detached by weathering along the bate of the rock. The flakes fall, expose an inner face to the action of the weather, and are themselves soon dissolved and carried out of sight.

There is, of course, very considerable difference in the rate at which different limestones tend to waste before atmospheric agencies. Those which contain an unusual percentage of argillaceous matter appear to waste at the highest rate; and this is the more especially the case if the rock in question has been more or less dolomitized, as have many of the Carboniferous Limestones that have formerly received magnesian infiltrations from the New Red Rocks—the commonest source of dolomitization in Britain. At the other extreme (so far as the writer's own observations go) stand the compact, well-bedded, limestones that include much bituminous matter in their composition. But the rate of waste of bituminous limestones is by no means a low one under favourable circumstances, as the following observations will show:—About forty years ago a very hard, compact, bituminous limestone, belonging to the Yoredale Series, had been broken up for road metal, on a cart road leading to a fell-side coal mine near Tailbrig, Westmoreland. After a time, the coal mine, and consequently the road leading to it, ceased to be used. So the road was left for about twenty-five years. The nature of the surface in the higher part of the road favoured the passage over it of thin sheets of surface-water, charged more or less with compounds derived from the decomposing vegetable matter of the moorlands above. After the interval mentioned above had elapsed, the present writer happened to notice that the limestone "macadam" had evidently undergone many changes in consequence of its prolonged exposure. The surface of the whilom angular fragments of limestone was etched and corroded into irregular pits

as if the rock had been steeped in weak acid. The characteristic glaze, due to the redeposition of thin films of carbonate of lime, imparted a curious artificial appearance to the stones. But the most remarkable feature was the projection of delicate portions of corals and other organisms in sharp and high relief above the general surface of the weathered stones. It was perfectly evident that, since the road had ceased to be used as a cart road, the surface-waters had etched away the limestone to a depth of at least one-sixth of an inch, leaving the sharp edges of the fossils standing out to that extent in relief, to testify to the quantity of the surrounding matrix that had been dissolved and carried away in the mean time. One could not feel sure that the slender, delicate, edges of the projecting fossils afforded correct data for determining the original surface exposed; but assuming that they did so, and that no more had been removed than we can now estimate from these data, the present state of the stones in question proves that even bituminous limestone may be dissolved away by atmospheric agencies at the rate of one inch in two hundred and fifty years. Here again we have to take further into account the accelerated waste consequent upon the development of additional planes of solution along the bedding and the bate.

Another case in which an approximate estimate of the quantity of limestone removed by atmospheric causes in a known time occurred near Penrith several years ago. In one of the cuttings on the Keswick Railway just south-west of Penrith, a bed of limestone belonging to the Yoredale Series was bared of glacial drift for a short distance. When newly exposed, the limestone presented the usual appearance of a striated and smoothly-polished surface, without a trace of any asperities due to projecting fossils. An exposure to the weather for a period of only ten years sufficed not only to roughen the surface of the limestone, but to lower the general surface of the rock to such an extent that some of the more durable fossils were left standing about one-thirtieth of an inch in relief. In other words the limestone was wasting away along that surface alone at the rate of one inch in three hundred years. In the present case the water affecting the stone must have been almost entirely free from any admixture derived from decomposing vegetable matter, and the rock surface must have remained dry except during showers. [At Blenco Station, just beyond, a slab of sandstone beautifully glaciated has been exposed to precisely the same conditions for about 25 years; but it shows no signs whatever of having undergone any waste in the mean time. The contrast between the behaviour of the two kinds of rock in this, as in the majority of the other cases that have come under my notice, is most striking and instructive.]

Within the last month (August, 1890), another illustration of an equally instructive nature has been observed. Twelve years ago the new railway between Leyburn and Hawes, in Wensleydale, was in process of construction, and the contractors naturally took advantage, wherever they could, of any quarries of building stone suitable for their requirements. When the station at Askrigg was

to be built, limestone was quarried close by in Millgill, not far from Millgill Fors. The rock is a slightly-argillaceous limestone, generally crowded with fossils. This was roughly dressed into shape, and finally chiselled along marginal fillets when the rock was built up as the quoins of the station and its surrounding buildings. I had occasion to stay a few hours at the station lately, and then took careful note of the condition of the stone at that time. After an exposure of twelve years the dressed surface of the stone in question is everywhere rough to the feel; and the general surface has been lowered by atmospheric waste in the mean time to such an extent that some of the more durable fragments of fossils remain in relief to about a twentieth of an inch. Assuming that the upper surface of the fossils represents the original dressed surface of the limestone quoins, then it is evident that the limestone has already wasted away at the rate of one inch in two hundred and forty years. This, however, is only the beginning of it: when the weather has eaten into the bedding planes and the bate of the rock, then the rate of waste will certainly be proportionate to the increased surface exposed to the attacks of the weather.

We have, in these facts, some kind of measure of the initial rate at which limestone is wasted along any given surface. Briefly summarized the facts are these:—

| | | | | | |
|---|---|---|---|---|---|
| The Kirkby Stephen tombstones had weathered at the rate of | 1 | inch in | 500 | years. |
| The Tailbrig "macadam" | ,, | ,, | 1 | ,, | 250 | ,, |
| The Penrith limestone | ,, | ,, | 1 | ,, | 300 | ,, |
| The Askrigg limestone | ,, | ,, | 1 | ,, | 240 | ,, |

A rough average based upon these observed facts would indicate as a kind of general rate of waste about one inch in three hundred years: that, of course, refers to waste along one plane, and does not take into account the greatly accelerated waste consequent upon the rock being attacked simultaneously along many different planes. I believe we shall not err greatly in assigning at least double the rate of erosion to limestone generally.

The bearing of these facts upon some larger phenomena of denudation will be indicated in a subsequent communication.

## NOTICES OF MEMOIRS.

### British Association for the Advancement of Science. Leeds, September 4th to 10th, 1890.

List of Titles of Papers read in Section C, Geology.

Professor A. H. Green, M.A., F.R.S., President.

The President's Address. (See p. 475.)

*Professor O. C. Marsh.*—On the gigantic *Ceratopsidæ* (or horned Dinosaurs) of North America.

*B. Holgate.*—The Carboniferous Strata of Leeds and its immediate Suburbs.

*B. Holgate.*—Some Physical Properties of the Coals of the Leeds District.

*G. W. Lamplugh.*—On the Boulders and Glaciated Rock-surfaces of the Yorkshire Coast.

*G. W. Lamplugh.*—East Yorkshire during the Glacial Period.

*G. W. Lamplugh.*—Report on an Ancient Sea Beach near Bridlington.

*J. F. Walker.*—On Liassic Sections near Bridport.

*T. De la Touche.*—On the Sounds known as the "Barisúl Guns," occurring in the Gangetic Delta.

*T. Tate.*—On the so-called "Ingleton Granite."

*W. A. E. Ussher.*—The Devonian Rocks as described in De la Beche's Report, Interpreted in Accordance with Recent Researches.

*Dr. H. Hicks.*—On Pre-Cambrian Rocks occurring as fragments in the Cambrian Conglomerates in Britain.

*Dr. H. Hicks.*—The Effects produced by Earth-movements on the Pre-Cambrian and Lower Palæozoic Rocks in some sections in Wales and Shropshire.

*C. S. Wilkinson.*—On the Mineral Resources of New South Wales.

*Dr. H. W. Crosskey.*—Report on Erratic Blocks.

*P. F. Kendall.*—The Glacial Phenomena of the Isle of Man.

*G. W. Lamplugh.*—On the Speeton Clays and their Equivalents in Lincolnshire.

*H. G. Seeley.*—On the Neural Arch of the Vertebræ in the Ichthyosauria.

*W. Brindley.*—The Marbles and other Ornamental Rocks of the Mediterranean.

*Dr. Tempest Anderson.*—On the Supposed Volcanic Eruption of Cape Reykjanæs, Iceland, in 1887.

*W. Cash.*—On a new Lepidodendron from the Halifax Hard Bed.

*J. R. Dakyns.*—On the Changes of the Lower Carboniferous Rocks in Yorkshire, from South to North.

*Dr. J. Crawford.*—Human Footprints in Recent Volcanic Mud in Nicaragua.

*Dr. J. Crawford.*—On the Geology of Nicaragua.

*J. C. Antrobus* and *Dr. F. H. Hatch.*—Preliminary Note on the Composition and Origin of the Cheshire Boulders.

*Dr. F. H. Hatch.*—On some West Yorkshire Mica-Trap Dykes.

*T. Tate.*—Note on Phillips' Dyke, Ingleton.

*Dr. H. J. Johnston-Lavis.*—Report on the Volcanic Phenomena of Vesuvius.

*A. R. Hunt.*—On the Origin of Saline Inclusions in the Crystalline Rocks of Dartmoor.

*J. Bickerton Morgan.*—On the Base of the Silurian in North-east Montgomeryshire.

*W. W. Watts.*—Geology of the Long Mountain on the Welsh Borders.

*Rev. E. Jones.*—The Exploration of Elbolton Cave.

*Dr. A. Irving.*—Physical Studies of an ancient Estuary.

*C. E. De Rance.*—Report on the Circulation of Underground Waters.

*Professor T. Rupert Jones.*—Report upon the Fossil Phyllopoda of the Palæozoic Rocks.

*G. R. Vine.*—Report on the Cretaceous Polyzoa.

*W. Whitaker.*—Suggestions on Sites for Coal-search in the South-east of England.

*Dr. P. H. Carpenter.*—On some points in the Morphology of the Cystides.

*Professor Silvanus Thompson.*—On the Source of the River Aire.

*O. W. Jeffs.*—Report on Geological Photographs.

*J. W. Davis.*—Fossil Fish of the West-Riding Coal-Field.

*A. Smith Woodward.*—On the Discovery of a Jurassic Fish-Fauna in the Hawkesbury Beds of New South Wales.

*A. Smith Woodward.*—Communications on behalf of *Professor Anton Fritsch* (of Prague). Restorations of the Palæozoic Elasmobranchs, *Pleuracanthus* and *Xenacanthus*.

*J. E. Marr.*—Report on the Registration of Type-Specimens.

*A. Bell.*—Report on the "Manure-Gravels" of Wexford.

*J. L. Lobley.*—On the Origin of Gold.

*R. G. M. Browne.*—On the Historic Evidence as to the Change of Sea-level off the South Coast of England.

*T. Hart.*—Notes on Volcanic Paroxysms.

Papers read in other Sections bearing on Geology and Palæontology :—

*Prof. O. C. Marsh.*—Cretaceous Mammals of North America.

*Prof. J. Milne.*—Report of the Committee on the Volcanic and Seismological Phenomena of Japan.

*Dr. Tempest Anderson* and *Dr. Johnston-Lavis.*—A Visit to the Skapten District of Iceland.

## REVIEWS.

I.—Geological Survey of Western Australia. Annual General Report for 1888–1889. By Harry Page Woodward, F.G.S., etc., Government Geologist. 8vo. pp. 60. (Perth, W.A., 1890.)

THE geologist in Western Australia has a fine field for original observations, for there is an area of upwards of a million square miles in which up to the end of 1887 very little had been done in the way of a systematic Geological Survey. Hitherto scarce a dozen geologists have plied their hammers in this vast territory, although some of them have done good and detailed work over limited tracts, and have forwarded collections of fossils to England for description. Many years must yet elapse before even the leading geological features of Western Australia can be marked out; but during the years 1888 and 1889 a great deal has been accomplished by the Government Geologist, Mr. Harry P. Woodward, whose Report is now before us. A Geological Surveyor in Britain would be astounded at the idea of mapping 64,000 and more square miles in one year; but such is the record of work done by this energetic geologist in Western Australia, and it is easy to calculate, in a rough way, the time that might be occupied in completing a geological sketch-map of the entire Colony.

The country has only been "settled" for about 200 miles inland, whereas it is 1450 miles in its greatest length and 850 miles in breadth. Mr. Harry Woodward, however, hopes to have examined

most of the settled country by the end of the present year, when he proposes to issue a geological map of the Colony, filling in such information concerning the interior as can be gained from the reports and maps of explorers. This will be a most valuable basis for further work, and especially useful to others interested in the subject.

In the present Report we find an historical account of the work of the previous observers, and detailed summaries of the observations made by the author, during his first two years of office. What will be most interesting to our readers is the general account given of the rocks at present known in Western Australia, and these are tabulated as follows :—

### Sedimentary Rocks.

| | | | |
|---|---|---|---|
| Cænozoic. | Quaternary. | Recent (Holocene). | Alluvium, River Gravels and Estuarine deposits, Sand Dunes, Raised Beaches, etc. |
| | | Pleistocene. | Ancient River Gravels, etc.<br>Lower Estuarine deposits, shelly limestones and sandstones of the coast. |
| | Tertiary. | Pliocene. | Ferruginous sandstones and variegated clays. |
| | | Eocene. | Coralline and chalky limestones with flints, calcareous and ferruginous sandstones and grits. |
| Mesozoic or Secondary. | | Cretaceous. | Chalky limestones with flints, sand, ferruginous sandstones and limestones, ferruginous nodular clay-stones, sands, clays and mudstones. |
| | | Jurassic. | *Oolites.*—Oolitic limestone, clay ironstone, ferruginous sandstone, grits and conglomerates.<br>*Lias.*—Ferruginous and variegated limestones, clays and ironstones. |
| Palæozoic or Primary. | | Carboniferous. | Sandstones, grits, conglomerates and ironstone, limestones, mudstones, micaceous clays and shales, with iron-pyrites, gypsum, and coal-seams. |
| | | Devonian. | Shales, indurated slates, limestones, coarse grits, and conglomerates. |
| | | Silurian and Metamorphic. | Clay-slate, limestones, marble, dolomite, sandstones, quartzites, and conglomerates. |
| Azoic ? | | Archæan (Metamorphic). | Slates, schists, serpentine, quartzite, gneiss, granitoid, and garnet rocks. |

### Igneous Rocks.

| | |
|---|---|
| Volcanic. | Basalt, Dolerite. |
| Plutonic. | Felstone, diorite (greenstone), syenite, granite. porphyry, amygdaloid. |

This is a goodly list of formations, while the sequence of strata and their striking correspondence in general lithological character with some of the European equivalents, is remarkable. It is stated that the next Annual Report will, if possible, contain a list of the fossils of the country.

The presence of Jurassic and Cretaceous rocks was first made known by Mr. F. T. Gregory in 1861, and large additions to our knowledge of the Oolitic and Liassic fossils were published by

Charles Moore in 1870.[1] Moore then remarked on the striking similarity between the matrix of the Australian specimens and the Lower Oolitic rocks of England with which he was so familiar; and he recognized twenty species of fossils as common to the two countries.

A few of the Carboniferous and Devonian fossils from Western Australia, lately described in the GEOLOGICAL MAGAZINE (for the present year) by Mr. A. H. Foord, Prof. Nicholson, and Dr. Hinde, are identified as belonging to European species; other Carboniferous forms were also described by Mr. Hudleston in 1883,[2] at which date there was no proof of the presence of Devonian strata in Western Australia. Indeed, in his Report, Mr. Woodward states that no fossils are known from the Devonian rocks, but we must not anticipate his remarks on the species so recently described from rocks of this age in the Colony. The subject of the sequence of organic remains in a tract so distant from us is of great interest, and especially when we find many facts corresponding with those known in Europe. The absolute identity of species in the two areas may be questioned by some specialists: but minute differences cannot affect the general question, although it is important to note them. What is of first importance is that the stratigraphical sequence in Australia be made clear with the aid of sections, and we trust the Government Geologist will supply these in future Reports. It will also be interesting to learn more of the Serpentine, which is placed among the Archæan (Metamorphic) rocks.

The subject that is of most concern to the Colonists is that of the Mineral Wealth, and this necessarily has occupied the chief share of Mr. Woodward's attention. Gold, and ores of Lead, Copper, and Tin, are to be had in profitable quantities, but the difficulties of access, the scarcity of water in some areas, and the cost of labour, have combined to arrest enterprise. There is Iron-ore "enough to supply the whole world," and there are ores of Antimony and Manganese, as well as large and very pure deposits of Kaolin. The Coal at present found appears to be of inferior character, and "where wood is so abundant and always close at hand, there is no demand for any, except a first-class steam coal." It is stated, however, that "Coal has recently been found at Wyndham, but though the sample sent down was of very fair quality, the size and extent of the seams have not yet been tested."

With regard to the Soils, it is observed that they are as good and as varied as in any part of the world, but large tracts of the best land are still heavily timbered. Some interesting remarks are made on the work of the White Ants, whose nests contain so much iron that "when a tree has been burnt in which they have built a nest, there will be found at its base a mass of iron clinker, looking just as if it had come out of a furnace."

It is interesting to learn that the south-west coast is rapidly rising, and indeed "many old colonists remember when land at Fremantle, now quite above the water-level, used daily to be covered by the tide."

[1] Q.J.G.S. vol. xxvi. pp. 229, 231. [2] *Ibid.* vol. xxxix. p. 582.

II.—Geological Survey of India. Memoirs, vol. xxiv. part 2, Physical Geology of the Sub-Himalaya of Garhwal and Kumaun. By C. S. Middlemiss, B.A. (Cantab).

As bearing on a question so much discussed as is that of the origin and growth of mountains, it seems strange that some very definite results published by the Geological Survey of India so long ago as 1864 regarding the greatest mountains in the world should have been generally ignored. It is to be hoped that this small geological scandal may be arrested by the latest publication of that Survey, here under notice. The ground is continuous with that to the west of the Ganges, described by me in Vol. III. of the Memoirs; and Mr. Middlemiss begins by quoting some recent instances of the neglect aforesaid, whereby absurdly erroneous statements are still made regarding the part taken by the Tertiary (Siwalik) rocks in the Himalayan mountain-system, although the correct view of that relation had been quite explicitly set forth by me, as has now been verified by more detailed work. I have humbly to plead guilty to the want of lucidity complained of by Mr. Middlemiss; the particular conclusions arrived at were indeed categorically stated,[1] but it is more or less excusable that these should have taken no hold when the evidence for them had to be painfully extracted from a maze of conflicting considerations. In the present Memoir it is duly admitted that when I took it up, the stratigraphy was practically unknown, and that I had to work with very imperfect maps on a small scale—the old edition of the Indian Atlas sheets; while the new work was started from a good base of information, and with the admirable large-scale maps of the new Forest Survey. Mr. Middlemiss has done full justice to these more favourable conditions. His work is given with a fulness of detail and a clearness of exposition that leave little to be desired.

The general result admits of being stated in a sentence: that, notwithstanding more or less of modification by reverse faulting, the main boundary of the sub-Himalayan zone with the higher mountains, as well as the several lines of contact between newer and older deposits within that zone, are primarily and approximately original limits of deposition. This is what I have maintained since 1864. The proof positive of such a relation is of course the production of a section showing actual original contact of newer upon or against older deposits at the boundary in question. Such a section I did present[2] of Siwalik conglomerates in original contact with bottom Nahan beds at the boundary near Tib, south of Nahan. The isolated remnant of the newer rock was indeed only a shred; still it was enough to swear by, if genuine, as I enthusiastically took it to be. Many years later, in 1881, Mr. R. D. Oldham called me to account upon this point; and on revisiting the spot with him, I admitted that the patches of gravel which I had fondly taken to be Siwalik more probably belonged to the recent high-level gravels.

[1] *Loc. cit.* p. 174. [2] *Loc. cit.* p. 108.

I immediately published[1] a retractation of my error; maintaining at the same time, upon what I held to be ample collateral evidence, that my view of the boundary was still essentially correct. With such an awful warning before him, Mr. Middlemiss was not likely to fall into the same mistake; indeed, the number and extent of the sections he describes and figures, from widely distant localities, showing original unconformable contact of this kind, leave no room for such a supposition. At other points along the same continuous boundary the contact is of the type so usual in this region—a steep plane with the older rocks overhanging the newer, sometimes in apparent conformable sequence and each in normal order, the middle limb of the folded flexure having been removed by overthrust. It is quite clear that a common phase of this action may be a complete simulation of a fault, normal or reversed, by the simple tilting of a denuded face of the upper limb of the flexure after the deposition of newer rocks against it, instances of which are given in Nos. I. and II. of the sections under notice. The fault at Jirinjala in Section V. seems uncalled for. Altogether, to speak of those boundaries, without qualification, as faults, is to ignore their primary and most interesting character. When in a continuous sequence of strata a folded flexure occurs, with fracture and overthrust, the plane of contact is a fault in the full sense of the word; but to describe the main boundary of the sub-Himalayan zone as a great fault is to open the door for the very blunder that Mr. Middlemiss has deplored. This is quite an ancient bone of contention with me.[2] I had expected to find some reflections by Mr. Middlemiss on the lines suggested by Mr. R. D. Oldham, in 1885,[3] that under the conditions supposed there must have been for every stage a fringing zone of boulder deposits, like the modern bhábar, of which the outer Siwalik conglomerates are the next preceding representative; and, that judging by analogy, the unrepresented bhábar deposits corresponding to the Nahan sandstone must have extended about twelve miles north of the present main boundary.

The "one minor discrepancy" noticed at page 111 between my work and his own, regarding a fourth possible sub-Himalayan group, disappears at once with the recognition of the Siwalik sand-rock on the north of the Kearda-Dehra dún. Again, at page 124, an alternative view is mistaken for the one I finally adopted—that elsewhere in the neighbourhood there is completely conformable sequence between strata that are strongly discordant along the lines of upheaval. At page 32, in his remarks on the main boundary, Mr. Middlemiss may have forgotten that at one spot, not in his area, where the Satlej crosses that boundary, the Subathu beds of the Sirmur area pass continuously, by a narrow band, into the sub-Himalayan zone, and there the Nummulitic beds and what may be Nahans are in normal succession. In that direction, in Kangra and Jamu, a much fuller subdivision of the sub-Himalayan system

[1] Records, vol. xiv. p. 169.
[2] Geol. Mag. 1869, p. 341; 1870, p. 473.
[3] Records, vol. xviii. p. 110.

will, I believe, have to be made out, as suggested in the Manual (p. 554). It is all very fine to object to the "torment" of conflicting hypotheses (p. 110), but for my part I never could find comfort in an artificial paradise.

There is one point that calls for more explicit notice. In my Memoir (p. 174) I recorded a conclusion of some general interest: that "The Krol group [*i.e.* the massive limestone], the youngest of the older rocks, though greatly denuded, had undergone little or no contortion along the outer zone of the mountain area, prior to the formation of the Subathu Nummulitic rocks." The statement was based upon the section at Subathu, where, on both sides of a steep synclinal fold of considerable width, the characteristic bottom bed of the Tertiary series occurs with complete parallelism upon slaty flags of the Infra-Krol horizon. In the Manual (p. 569) I re-affirmed the statement, confirming it in part by evidence from the sub-Himalayan zone in Jamu, where the same typical bottom Tertiaries regularly overlie the massive limestone. I thus laid further stress upon the Subathu section, as proving that elevation with great denudation had taken place much earlier in the eastern area. The affirmations as to denudation and contortion are distinct, and should be severally maintained or refuted. The geologist should rarely indulge in the word "impossible"; but I do assert it as to me inconceivable that the contact relation at Subathu could have been brought about unless the Krol group had been removed by denudation prior to the deposition of the Subathu beds, and unless the Infra-Krol beds had then been unplicated. In the immediate neighbourhood, sections abound showing the usual crushed and confused contact. Until that section at Subathu is specifically disposed of, I must hold to it.

Mr. Middlemiss endeavours gently to extricate me from this position. He says (p. 4) that in repeating it in the Manual I unfortunately trusted largely to the sections in Jamu; but on the face of it this is wrong, for half of my affirmation rests solely on the Subathu section. To this section Mr. Middlemiss only refers in a footnote; and it does not seem certain whether he had ever seen it. It does not appear as if Mr. Middlemiss were quite certain of this feature in his own ground. In Section VI. the Subathu beds and the underlying fossiliferous Tal beds are in regular sequence upon the massive limestone, while in Section IX. the two former, without the limestone, rest in rough parallelism on the old slates, without faulting; and his facts in favour of an earlier plication of the Himalayan rocks are only quotations of wholesale differences of strikes in that region. Of course the presumption seemed all in favour of such earlier disturbance with plication of the older rocks; but I thought it right to point out that the most particular facts in hand would point the other way, in the direction of an origin in continental elevation by bossellement as suggested by De Beaumont. Such references to elementary theories give point to stray remarks, and by no means imply the advocacy of the developments that may have grown out of the said theories.

The general remarks upon mountain formation in Mr. Middlemiss's concluding chapter are the least satisfactory part of his work. Mr. Mellard Reade's book on "The Origin of Mountain Ranges" is taken as the fulcrum of discussion; and some effective execution is done in the way of demolishing errors of "fact," but the *reductio ad absurdum* of the "principle" involved is not complete. Some caution might have been suggested by the knowledge that Babbage and Herschell were the promoters of the said principle in this cause, for such men were not likely to commit absurd blunders in the elements of mechanical physics. The key sentence in Mr. Middlemiss's argument (p. 131) is, to say the least of it, obscure; that "great sedimentation of this kind can only take place by concomitant sinking of the sea-bottom; so that the rise of the isogeotherms being interpreted means merely the sinking of the floor on which the deposits were laid down." It certainly does mean that much; but the form of expression is incomplete or even misleading, for the process is not wholly a rising of the isogeotherms, but also a sinking of the strata into zones of higher temperature with the inevitable concomitant expansion, which through tangential resistance must (unless some line of less resistance is already established) result in the plication with elevation of the strata concerned, to which action the origin of true mountains is plausibly attributed by the theory in question. Mr. Middlemiss seems to ignore the significant distinction between continental elevation and "true mountains." The total rejection of the Babbage-Herschell principle is the more strange as this starts from the same point—the "condition of approximate hydrostatical equilibrium" of the earth's crust—as does the discussion of the same question by Mr. Fisher, of which so much approval is deservedly expressed. It is not unlikely that the subsidence of the plains' deposits into regions of higher temperature may be a factor in the continued rise and compression of the sub-Himalayan zone, which Mr. Middlemiss emphasizes as if it had been denied. It is clear, too, that the rise extends to the whole of the outer Himalaya, else the transverse river gorges would have become lake-basins, as has occurred in the Alps. But Mr. Middlemiss does not sufficiently keep in mind that the mountains he refers to are but the southern face of the Himalayan massif, the crest of which must, as indicated by the drainage lines,[1] have been far to the north of the present range of greatest elevations. The decadence suggested by me was assigned to that central region. The unfortunate expression "life history," as applied to things that have no life, might have helped him here as it seems to have confused him elsewhere: for a man's brain may mature while his limbs go to the bad, or *vice versa*. Rhetoric is an unsafe and unsavoury ingredient in scientific work. HENRY B. MEDLICOTT.

[1] Manual, p. 675.

# REPORTS AND PROCEEDINGS.

## Sixtieth Annual Meeting of the British Association for the Advancement of Science,

## Leeds, 1890.

### Address to the Geological Section of the British Association.

By Professor A. H. Green, M.A., F.R.S., of the University of Oxford, President of the Section, September 4th, 1890.

THE truth must be told; and this obliges me to confess that my contributions to our stock of geological knowledge, never very numerous, have of late years been conspicuously few, and so I have nothing to bring before the Geological Section that can lay any claim to be the result of original research.

In fact, nearly all my time during the last fifteen years has been taken up in teaching. This has led me to think a good deal about the value of geology as an educational instrument, and how its study compares with that of other branches of learning in its capability of giving sinew and fibre to the mind, and I have to ask you to listen to an exposition of the notions that have for a long time been taking shape bit by bit in my mind on this subject.

I am not going to enter into the question, handled repeatedly and by this time pretty well thrashed out, of the relative value of natural science, literature, and mathematics as a means of educational discipline; for no one who is lucky enough to know a little of all three, will deny that each has an importance of its own and its own special place in a full and perfect curriculum. The question which is the most valuable of the three I decline to entertain, on the broad general ground that "comparisons are odorous," and for the special reason that the answer must depend on the constitution of the mind that is to be disciplined. I might quite as reasonably attempt to lay down that a certain diet which suits my constitution and mode of life, must agree equally well with all that hear me.

I need scarcely say that nothing would induce me, if it could possibly be helped, to say one word that might tend to disparage the pursuit to which we are all so deeply attached. But I cannot shut my eyes to the fact that, when geology is to be used as a means of education, there are certain attendant risks that need to be carefully and watchfully guarded against.

Geologists, and I do not pretend myself to be any better than the rest of them, are in danger continually of becoming loose reasoners. I have often had occasion to feel this, and I recall a scene which brought it home to me most forcibly. At a gathering, where several of our best English geologists were present, the question of the causes of changes of climate was under discussion. The explanation which found most favour was a change of the position of the axis of rotation within the earth itself; and this, it was suggested, might have been brought about by the upheaval of great bodies of continental and mountainous land where none now exist, and an accompanying depression of the existing continents or parts of them. That such a redistribution of the heavier material of the earth would result in some shifting of the axis of rotation admits of no doubt. The important question is, How much? What degree of rearrangement of land and sea would be needed to produce a shift of the amount required? It is purely a question of figures, and the necessary calculations can be made only by a mathematician. I ventured to suggest that some one who could work out the sum should be consulted before a final decision was arrived at, for I knew perfectly well that not one of the company present could do it. But if I say that my advice met with scant approval, I should represent very inadequately the lack of support I met with. The bulk of those present seemed quite content with the vague feeling that the thing could be done in the way suggested, and there was a general air of indifference as to whether the hypothesis would stand the test of numerical verification or not.

I could bring many other similar instances which seem to me to justify the charge I have ventured to make; but it will be more useful to inquire what it is that has led to a failing, which, if it really exist, must be a source of regret to the whole brotherhood of hammerers.

The reason, I think, is not far to seek. The imperfection of the Geological Record is a phrase as true as it is hackneyed. No more striking instance of its correctness can be found than that furnished by the well-known Mammalian jaws from the Stonesfield slate. The first of these was unearthed about 1764; others, to the number of some nine, between then and 1818. The rock in which these precious relics of the beginning of Mammalian life occur has been quarried without intermission ever since; it has been ransacked by geologists and collectors without number; many of the quarrymen know a jaw when they see it, and are keenly alive to the market value of a specimen; but not more than six or seven of these prized and eagerly-sought-after fossils have turned up during the last seventy years.

Then again how many of the geological facts which we gather from observation admit of diverse explanation. Take the case of *Eozoon Canadense*. Here we have structures which some of the highest authorities on the Foraminifera assure us are the remains of an organism belonging to that order; other naturalists, equally entitled to a hearing, will have it that these structures are purely mineral aggregates simulating organic forms. And hereby hangs the question whether the limestones in which the problematical fossil occurs are organic, or formed in some other and perhaps scarcely explicable way.

And this after all is only one of the countless uncertainties that crowd the whole subject of invertebrate palæontology. In what a feeble light have we constantly to grope our way when we attempt the naming of fossil Conchifers for instance. The two species *Gryphæa dilatata* and *G. bilobata* furnish an illustration. Marked forms are clearly separable, but it is easy to obtain a suite of specimens, even from the Callovian of which the second species is said to be specially characteristic, showing a gradual passage from one form into the other. And over and again the distinctions relied upon for the discrimination of species must be pronounced far-fetched and shadowy, and are, it is to be feared, often based upon points which are of slender value for classificatory purposes. In the case of fossil plants the last statement is notoriously true, and yet we are continually supplied with long lists of species which every botanist knows to be words and nothing more, and zonal divisions are based upon these bogus species and conclusions drawn from them.

It is from data such as have been instanced, scrappy to the last degree, or from facts capable of being interpreted in more than one way, or from determinations shrouded in mist and obscurity, that we geologists have in a large number of cases to draw our conclusions. Inferences based on such incomplete and shaky foundations must necessarily be very largely hypothetical. That this is the character of a great portion of the conclusions of geology we are all ready enough to allow with our tongue—nay, even to lay stress upon the fact with penned or spoken emphasis. But it is open to question whether this homage at the shrine of logic is in many cases anything better than lip-service; whether we take sufficiently to heart the meaning of our protestations, and are always as alive as our words would imply to the real nature of our inferences.

A novice in trade, scrupulously honest, even morbidly conscientious to begin with, if he lives among those who habitually use false scales, runs imminent risk of having his sense of integrity unconsciously blunted and his moral standard insensibly lowered. A similar danger besets the man whose life is occupied in deducing tentative results from imperfectly ascertained facts. The living, day by day, face to face with approximation and conjecture, must tend to breed an indifference to accuracy and certainty, and to abate that caution and that wholesome suspicion which make the wary reasoner look well to his foundations, and resolutely refuse to sanction any superstructures, however pleasing to the eye, unless they are firmly and securely based.

If I am right in thinking that the mental health of the geologist of matured experience and full-grown powers is liable to a disorder of the kind I have indicated, how much greater must the risk be in the case of a youth, in whom the reasoning faculty is only beginning to be developed, when he approaches the study of geology! And does it not seem at first sight that that study could scarcely be used with safety as a tool to shape his mind, and so train his bent that he shall never even have a wish to turn aside either to the right hand or to the left from the strait path that leads through the domain of sound logic?

That it is hazardous, and that evil may result from an incautious use of geology as an educational tool, I entertain no doubt. The same may indeed be said of many

other subjects, but I feel that it is specially true in the case of geology. But I should be guilty of that very haste in drawing conclusions against which I am raising a warning word, if I therefore inferred that geology can find no place in the educational curriculum.

To be forewarned is a proverbial safeguard, and those who are alive to danger will cast about for a means of guarding against it. And there are many ways of neutralising whatever there may be potentially hurtful in the use of geology for educational ends. It has been said that the right way to make a geologist is not to teach him any geology at all to begin with. To send him first into a laboratory, give him a good long spell at observations and measurements requiring the minutest accuracy, and so saturate his mind with the conception of exactness that nothing shall ever afterwards drive it out. If a plan like this be adopted, it is easy to pick out such kinds of practical work as will not only breed the mental habits aimed at, but will also stand him in good stead when he goes on to his special subject. Goniometrical measurements and quantitative analysis will serve the double purpose of inspiring him with accurate habits of thought, and helping him to deal with some of the minor problems of geology. And I cannot hold that this practice of paying close attention to minute details will necessarily unfit a man for taking wider sweeps and more comprehensive views later on. That habit comes naturally to every man who has the making of a geologist in him directly he gets into the field. Put such a man where a broad and varied landscape lies before him, teach him how each physical feature is the counterpart of geological structure, and breadth of view springs up a native growth. I do not mean to say that the plan just suggested is the only way of guarding against the risk I have been dwelling upon. There are many others. This will serve as a sample to show what I think ought to be aimed at in designing the geological go-cart. And any such mind-moulding leads, be assured, not to hesitancy and doubt, but to conclusions, reached slowly it may be, but so securely based that they will seldom need reconstruction.

There is another aspect of the question. The uncertainties with which the road of the geologist are so thickly strewn have an immense educational value, if only we are on our guard against taking them for anything better than they really are. Of those stirring questions which are facing us day by day and hour by hour, none perhaps is of greater moment than the discussion of the value of the evidence on which we base the beliefs that rule our daily life. A man who is ever dealing with geological evidence and geological conclusions, and has learned to estimate these at their real value, will carry with him, when he comes to handle the complex problems of morals, politics, and religion, the wariness with which his geological experience had imbued him.

Now I trust the prospect is brightening. Means have been indicated of guarding against the danger which may attend the use of geology as an educational instrument. Need I say much to an audience of geologists about the immense advantages which our science may claim in this respect? In its power of cultivating keenness of eye it is unrivalled, for it demands both microscopic accuracy and comprehensive vision. Its calls upon the chastened imagination are no less urgent, for imagination alone is competent to devise a scheme which shall link together the mass of isolated observations which field work supplies; and if, as often happens, the fertile brain devises several possible schemes, it is only where the imaginative faculty has been kept in check by logic that the one scheme that best fits each case will be selected for final adoption. But, above all, geology has its home, not in the laboratory or study, but *sub Jove*, beneath the open sky; and its pursuit is inseparably bound up with a love of Nature, and the healthy tone which that love brings alike to body and mind.

And what does the great prophet of Nature tell us about this love?

> The boy beholds the light and whence it flows;
> The man perceives it die away,
> And fade into the light of common day.

Will it not then be kind to encourage the boy to follow a pursuit which will keep alive in him a joy which years are too apt to deaden; and will not the teaching of geology in schools conduce to this end? Geology certainly should be taught in schools, and for more prosaic reasons, of which the two following are perhaps the most important. Geography is essentially a school subject, and the basis of all geographical teaching is physical geography. This cannot be understood

without constant reference to certain branches of geology. Again how many are the points of contact between the history of nations, the distribution and migrations of peoples, and the geological structures of the lands they have dwelt in or marched over.

But geology is not an easy subject to teach in schools. The geology of the ordinary text-book does not commend itself to the boy-mind. The most neatly-drawn sections, nay, even the most graphic representations of gigantic and uncouth extinct animals, come home to the boy but little, because they are pictures and not things. He wants something that he can handle and pull about; he does not refuse to use his head, but he likes to have also something that will employ his hands at the same time.

The kind of geology that boys would take to is outdoor work; and, of course, where it can be had, nothing better could be given them. A difficulty is that field work takes time and filches away a good deal of the intervals that are devoted to games. Still cross-country rambles and scrambling about quarries and cliffs are not so very different from a paper-chase; and if the teacher will only infuse into the work enough of the fun and heartiness which come so naturally in the open air, he need not despair of luring even the most high-spirited boy, every now and then, away from cricket and football.

But there are localities not a few—the Fen country, for instance—where it is scarcely possible to find within manageable distance of the school the kind of field-geology which is within the grasp of a beginner. But even here the teaching need not be wholly from books. The best that can be done in such cases is to make object-lessons indoors its basis. For instance, give a lad a lump of coarsish sandstone; let him pound it and separate by elutriation the sand grains from the clay; boil both in acid, and dissolve off the rusty coating that colours them; ascertain by the microscope that the sand grains are chips and not rounded pellets, and so on. All such points he will delight to worry out for himself; and, when he has done that, an explanation of the way in which the rock was formed will really come home to him. Or it is easy to rig up contrivances innumerable for illustrating the work of denudation. A heap of mixed sand and powdered clay does for the rock denuded; a watering-can supplies rain; a trough, deeper at one end than the other, stands for the basin that receives sediment. By such rough apparatus many of the results of denudation and deposition may be closely imitated, and the process is near enough to the making of mud-pies to command the admiration of every boy. It is by means like these that even indoor teaching of geology may be made lifelike.

I need not dwell upon the great facts of physical geology which have so important a bearing on geography and history; but I would, in passing, just note that these too often admit of experimental illustration, such for instance as the well-known method of imitating the rock folding caused by earth-movements. I would add that wherever in speaking of school teaching, I have used the word "boy," that word must of course be taken to include "girl" as well.

In conclusion I should like to give you an outline of the kind of course I endeavour to adopt in more advanced teaching in the case of students who are working at other subjects as well and can give only a part of their time to geology. During the first year the lectures and bookwork should deal with physical geology. In the laboratory the student should first make the acquaintance of the commoner rock-forming minerals, the means of recognizing them by physical characters, blowpipe tests, and the simpler methods of qualitative analysis, and may then go on to work at the commoner kinds of rocks and the elements of microscopic petrography. During the summer months I would take him into the field, but not do more than impress upon him some of the broader aspects of outdoor work, such as the connection between physical feature and geological structure.

During a second year stratigraphical geology should be lectured upon and studied from books, and so much of animal morphology as may be necessary for palæontological purposes should be mastered. The practical work would lie mainly among fossils, with a turn every now and again at mineralogy and petrology to keep these subjects going. Out of doors I would not yet let the student attempt geological mapping, but would put into his hands a geological map and descriptions of the geology of his neighbourhood, and he would be called upon to examine in minute detail all accessible sections, collect and determine fossils, and generally see how far he can verify by his own work the observations of those who have gone before him.

Indoor work during the third year would be devoted to strengthening and widening

the knowledge already gained. Out of doors the student should attempt the mapping of a district by himself. It will be well, if there is any choice in the matter, to select one in which the physical features are strongly marked.

This sketchy outline must serve to indicate the notions that have grown up in my mind on the subject now before us, and the methods I have been led to adopt in the teaching of geology. I trust that they may be suggestive, and may call forth that kindly and genial criticism with which the brotherhood of the hammer are wont to welcome attempts, however feeble, to strengthen the corner-stones and widen the domain of the science we love so well, and to enlarge the number of its votaries.

## CORRESPONDENCE.

### PRIORITY OF NOMENCLATURE.

Sir,—May I ask your opinion on a question of nomenclature? About 15 years ago I discovered in Shropshire the formation which Phillips had previously found in the Malvern Hills, and had called the Hollybush Sandstone. Quite recently, Prof. Lapworth, writing in this Magazine, referred to this rock as the "Comley Sandstone," taking the name from the locality where my typical section is seen, and Prof. Blake has adopted the new nomenclature. Is this change of name in accordance with usage? We call the "Wenlock Limestone" by that name, whether it occurs in Shropshire or the Malvern Hills, and why should we not call the "Hollybush Sandstone" by Phillips' name, whether it is found in the Malvern Hills or in Shropshire?

Ch. Callaway.

Wellington, Shropshire, *August 22nd*, 1890.

### THE ELEVATION OF THE WEALD.

Sir,—In the rapid increase of geological literature, some of our early papers may easily be overlooked, and facts unwittingly repeated as novel which had already been noticed; but it may not often happen that the first observer is made the disciple of the second. I have no objection to legitimate criticism; but there is an objection to this obliteration of landmarks, otherwise I should not now care to address you. In Dr. Irving's note "On the Elevation of the Weald," in this month's number of your Magazine, he draws attention to the fact that in 1883 he pointed out that there was evidence of the encroachment of the sea upon the Upper Chalk in Eocene times, and that *this conclusion is accepted by Professor Prestwich.* This might lead the reader to suppose that I had overlooked this point, and that my notice of it in my paper "On the Westleton Beds" (1889), to which he refers, was in consequence of his 1883 paper. Had that been the case, I should not have failed to acknowledge, and that most willingly, my authority for so leading a fact. If, however, Dr. Irving will kindly refer to my paper "On the Thanet Sands" in Q.J.G.S. for 1852, pp. 256–260,[1] or to "The Ground Beneath Us," pp. 70–79, 1847, he will find the question discussed at some length, and *facts* and *sections* given to show that the dome of the Weald was raised after Cretaceous times, and that the Chalk

[1] Mr. Irving will find this reference in the paper which is the cause of his remarks.

was largely planed down by the early Tertiary seas, its flints contributing to the pebbles of the Woolwich and Reading beds.

Having pen in hand, I am induced to notice another slight matter in Mr. Irving's paper. He speaks of the Lenham sands as though they were first shown to be of Diestian age in 1888. He will find that that was the conclusion I arrived at in 1857 (Q.J.G.S. p. 328) and repeated in 1872 (Q.J.G.S. pp. 134, 478) and 1886 ("Geology," Vol. I. pp. 141, 303). The article in "Nature," 1888, to which he refers, is a friendly corroboration of the conclusion I had expressed. Nor were the sands on the Downs some miles further westward assumed to be contemporaneous "on the ground of approximate equality of altitude above the sea," but in that of position and structure.

Mr. Irving's observations about the Raised Beaches of Sussex described by me in 1858, and others in the Westleton shingle, might also call for some remarks; but these would lead me too far. I am also unable to follow Dr. Irving in the larger and more theoretical questions on which he enters, and respecting which we shall be better able to judge when he gives us, which I hope he will in some future paper, in *detail the local evidence* upon which his views are based.

JOSEPH PRESTWICH.

SHOREHAM, KENT, *Sept.* 10, 1890.

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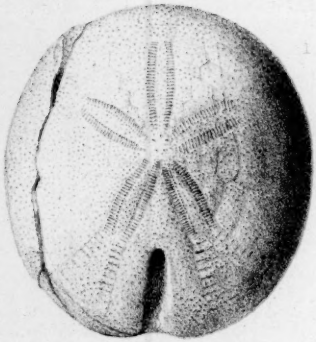
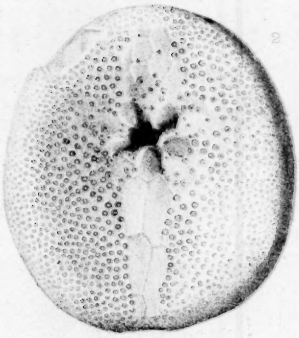
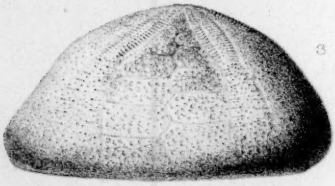
## STANDARDS OF MEASUREMENT.

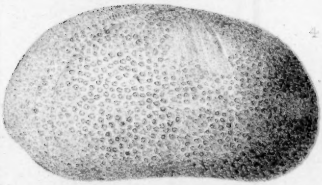
SIR,—Will you kindly permit me to direct the attention of the readers of the GEOLOGICAL MAGAZINE to an objectionable feature in the writings of many of our modern geologists, namely, the use, or rather misuse, of the French metrical standard of measurements instead of the English imperial standard. There are numbers of earnest students of geology who, like myself, read eagerly and carefully, as they are issued, the Quarterly Journal, Proceedings of the Geologists' Association, and the GEOLOGICAL MAGAZINE, but being unacquainted with the French language or their standard of weights and measures, they are unable to grasp the full import of many of the learned and highly instructive papers and articles which adorn the pages of the above-mentioned journals. These students are perfectly familiar with the English standard, and any measurement from 1/16th of an inch to a fathom, or even to a mile, furnishes at once, without any mental effort, a perfectly accurate impression of size or distance, while those given according to the French standard only convey impressions of the most indefinite kind. Moreover, when we take into consideration the fact that the papers and articles referred to are written by Englishmen, published in English journals, and many of them are read before English societies, it is greatly to be deplored, not only that their usefulness is marred, but also that an important part of their contents is rendered practically unintelligible to a very large number of readers by the introduction of foreign measures and quantities. The metrical system of measures may be superior to the English imperial standard in some respects, but it is not likely that the former will ever take the place of the latter, either in England or her numerous and populous colonies, while the use of a dual system must of necessity be a fruitful source of confusion and annoyance. I must state, however, that some of the writers who use the metrical system, take the trouble to add to the measurements given in that standard, their approximate equivalents according to the imperial standard, and if all would adopt that course, or still better, reverse the order, there would be no further cause for complaint.

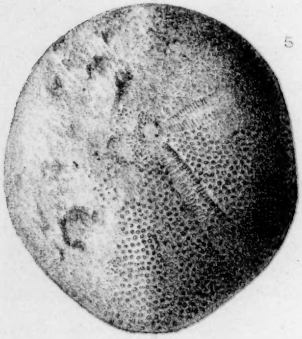
KESWICK, *Sept.*, 1890. JOHN POSTLETHWAITE.

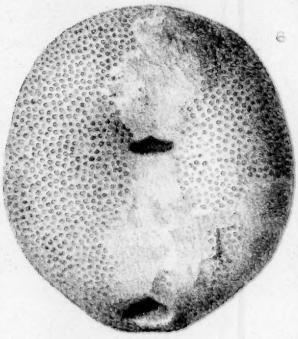


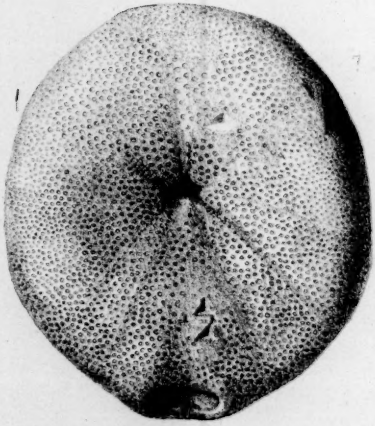



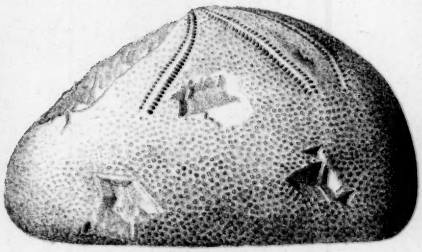



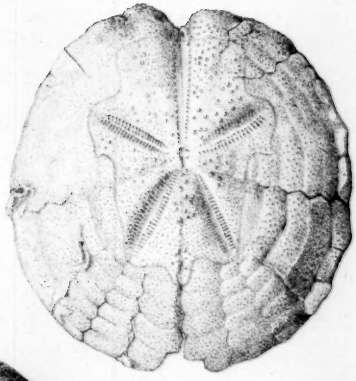



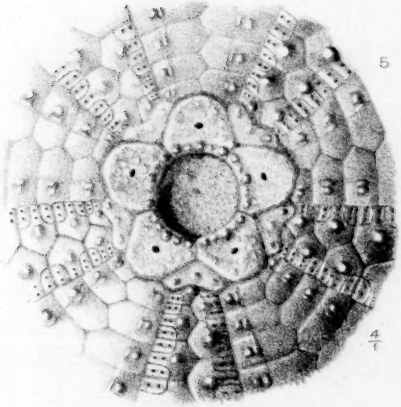



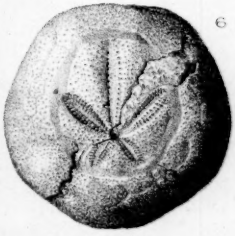



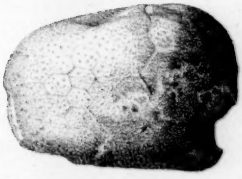



South Australian Echinoidea






G.M. Woodward del. et lith.

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South Australian Echinoidea.